POWER PLANT ENGINEERING

Trade-mark reg. U. S. Pat. Office

VOL. XXIV CHICAGO, APRIL 15, 1920 No. 8

Serving Indiana's Mining Fields

UNUSUAL LOAD CHARACTERISTICS AND ABUNDANT FUEL SUPPLY INSURE ECONOMICAL AND EFFICIENT OPERATION OF EDWARDSPORT POWER PLANT

ECONOMICAL AND EFFICIENT power-plant operation depends not only upon the cost of the various commodities required in the manufacturing or production process, but also to a marked extent upon the characteristics of the load. Naturally short and comparatively high peaks such as are ordinarily encountered in central station work and particularly so where lighting loads predominate require the installation of apparatus used but a comparatively short length of time each day, resulting in exceedingly heavy overhead charges, while with relatively smooth load curves, boilers, generating units and auxiliary equipment may be made to carry full-rated load the greater part of the 24 hr.; as a consequence, a high load factor ensues. The desirability of a day load for central stations is therefore obvious. Frequently, however, this is difficult to obtain and as a rule when such load is secured, the demand for power varies to such an extent that, while the load factor is improved, overall economy may be increased but little, primarily because of the rapid fluctuations in load encountered.

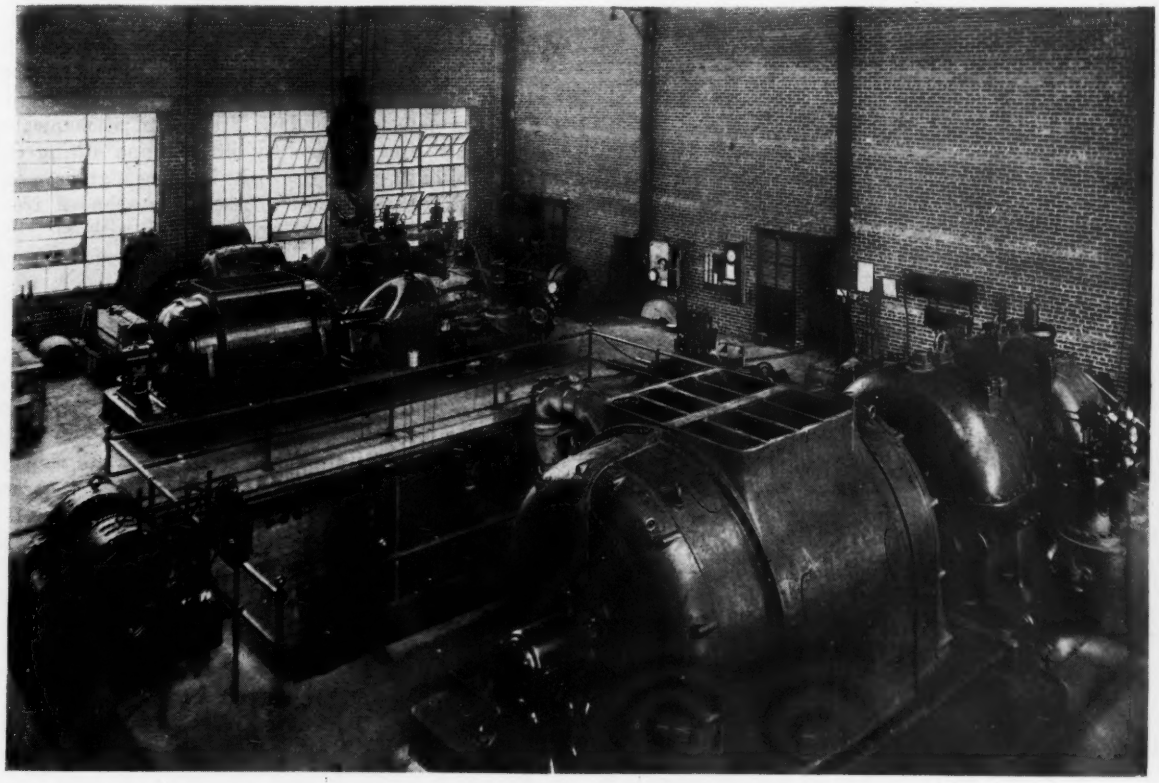


FIG. 6. GENERAL VIEW OF TURBINE ROOM

Practically ideal conditions would obtain with a uniformly constant day load filling the valley between the early morning and evening lighting peaks. It is because such a character of load is encountered that the plant of the Indiana Power Co., located at Edwardsport,

Ind., has been able to operate at a minimum cost and thereby give to its customers the privilege of unusually low rates for electric energy. In addition, it is in the heart of the Indiana coal fields, thus insuring an adequate, continuous and uninterrupted supply of fuel, and, because of its close proximity to the west fork of the White River, water at all seasons of the year for boiler feed and condensing purposes. The coal, while ordinarily obtainable from any one of the numerous mines in the vicinity, is, as a rule, secured from a mine owned by the Indiana Power Co., located at Bicknell, but a few miles distant from Edwardsport.

Realizing the detrimental effects of induction motors on the power factor of a transmission system, arrangements have been made whereby the heaviest power users, the coal mines, have installed synchronous converters. With proper degree of field excitation carried on these machines, not only has the lagging power factor, due to induction apparatus, been neutralized, but not infrequently do the station meters indicate a system leading power factor ranging from 0.95 to 1.00.

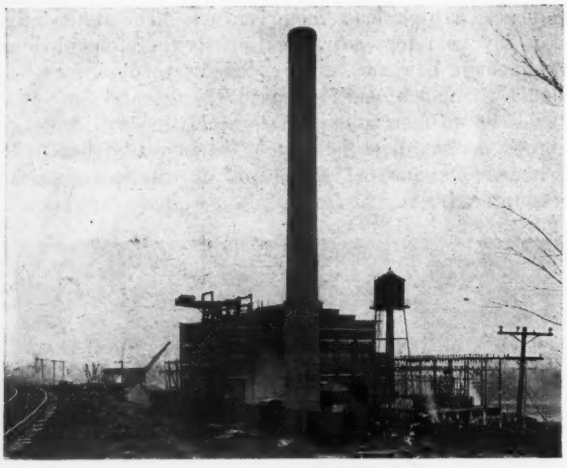


FIG. 1. EXTERIOR VIEW OF EDWARDSPORT POWER HOUSE

Although a number of other older steam plants are maintained in reserve for emergency service, the Edwardsport station is depended upon to serve the transmission system, a network of 33,000-v. lines covering the counties of Sullivan, Knox, Daviess, Greene and Pike in Indiana, and the counties of Lawrence, Richland and Crawford in Illinois. Current transmitted to Illinois is wholesaled to the Central Illinois Public Service Co. Energy is also sold in Indiana to the Wabash Valley Electric Co. In all, 30 communities with a combined population of over 100,000, and 26 coal mines are served.

Load growth has been almost phenomenal. This is evidenced by the increase in station output, which has tripled during the year 1919. As a consequence, the capacity of the existing power house will soon be reached and piling is now being driven for the foundations of an addition to house two 6250-kv.a. turbine-driven units and the boiler room equipment required to supply them with steam. The peak, which occurs at 10 o'clock each morning, is about 7000 kw., and is sustained several hours; this will undoubtedly exceed 10,000 kw. within the present year.

The Power House

To one visiting the Edwardsport power house the outstanding features are the unusually simple schemes of arrangements employed. The result of this has been a station constructed at a minimum of cost and one capable of being operated in such a way as to insure continuity of service under the most adverse conditions. The unit system is employed throughout, that is each turbo-generating unit is ordinarily supplied with steam by its individual set of boilers and supplies energy to its own bank of transformers, which feed the outgoing high-tension transmission lines. Means have, however, been provided whereby in case of emergency any or all of the boilers may be made to supply steam to any turbine and by means of the proper system of interconnection the step-up transformers may be thrown onto either generating set or, if so desired, the two banks of transformers installed can be operated in parallel.

Figures 1 and 2 illustrate the plant as it appears today and the general arrangement of the present equipment and that to be installed in the addition now under erection. The existing structure, which, together with machine foundations, rests on a concrete mat carried by piling, is of steel, concrete and brick and has overall dimensions of 80 by 121 ft. It consists of a boiler room and a turbine room, with basement below for such equipment and apparatus as that employed for the handling of the ashes, the condensers and auxiliaries and some of the pumps. The exposed brickwork, both interior and exterior, is dark red with white trim and, in order to present a harmonious appearance to the whole, all steel work has been painted the same color.

Two rows of large windows fitted with mechanically operated sash provide excellent illumination during the hours of daylight, while for night lighting high-powered lamps have been installed. These are suspended from the upper steel work and are provided with metallic enameled reflectors; in addition to these are side brackets for local illumination.

Coal Delivery and Ash Disposal

Due to the fact that this station has been located at the very mouths of the mines, no necessity exists for any extensive coal storage; although, as shown in Figs. 2 and 4, a concrete pit, having a capacity of approximately 1000 tons, has been provided along the west side of the building. Trestles carrying track allow the cars delivering coal to the plant to be run directly over the storage pit, thus enabling the prompt release of the cars either by dumping the coal into the pit or raising it to the bunker above the boiler room. These bunkers, which are of reinforced concrete, are capable of holding about 250 tons of the fuel, which is delivered to them by means of a cantilever crane arranged to travel above the bunkers the entire length of the boiler room.

The crane used for this purpose is electrically operated, is fitted with a 1½-yd. bucket and has a rated lifting and carrying capacity of 35 tons per hour. The coal is dumped through large hatchways in the roof of the boiler house and may be deposited directly into the bunkers or caused to pass through a single-roll crusher of the traveling type. Thus, as but one hatchway can be used at a time, a single crusher is made to serve the entire plant.

The company also has a locomotive crane and is thereby enabled to create immense reserve coal storage along its private siding. This crane also affords an emergency source of coal supply in the event that the regular cantilever coal crane is down for repairs.

Downspouts feed the fuel to the underfeed stokers with which the boilers are equipped and when consumed the remaining ashes are dumped into concrete receiving hoppers. These are fitted with gate valves enabling the ash men to discharge the refuse directly into small cars operating along a narrow-gage system of tracks. The ash cars are raised to the ground level by means of a hydraulic lift and are dumped outside of the power house, the ashes and cinders being at the present time extensively used for filling purposes.

Steam Generation and Distribution

Each of the four boilers at present installed is of the water-tube type and is equipped with an underfeed stoker having seven retorts. They have a nominal rating of 600 hp., although with the forced draft fans in operation and of which there are two, each driven by a 76-hp. turbine, 300 per cent of rated capacity may be realized.

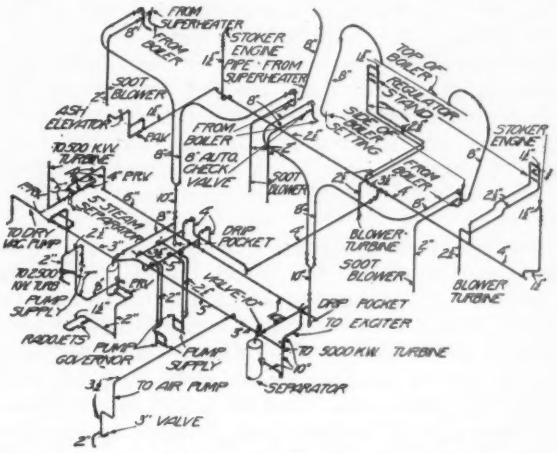


FIG. 3. ISOMETRIC DRAWING OF MAIN STEAM PIPING

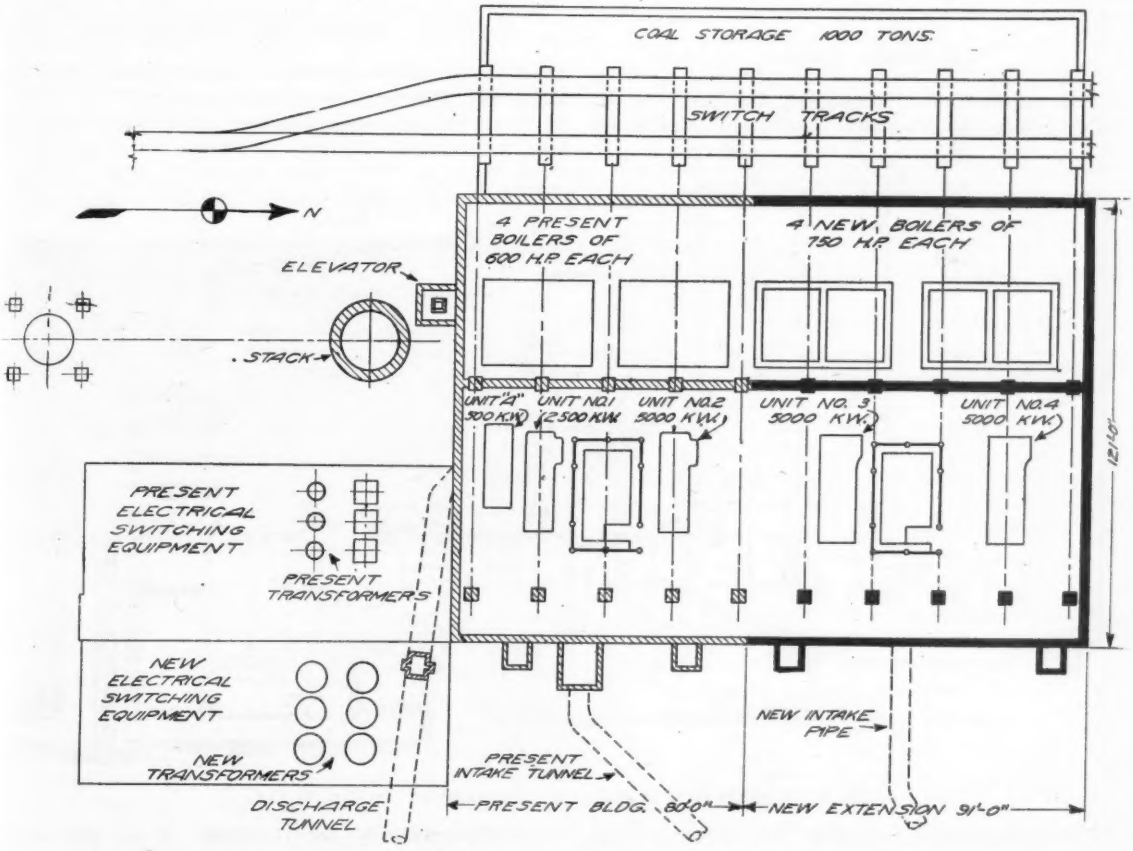


FIG. 2. GENERAL LAYOUT OF PRESENT STATION WITH ADDITION NOW UNDER CONSTRUCTION

The steam is ordinarily generated at a pressure of 200 lb. gage and is superheated 150 deg. F.

Water for both boiler makeup and condenser service may be taken either from any one of five wells or the river. Before fed to the boilers, however, the water is pumped through a softener operated in conjunction with two twin-connected open feed-water heaters rated at 2000 hp. each. From here it is delivered to the boilers by a 250-gal. per minute 3-stage centrifugal pump turbine driven and operating at a speed of about 3000 r.p.m. or by a 300-gal. per minute duplex reciprocating pump.

Close observation is maintained of the performance of the boilers. Each is fitted with a steam-flow meter, an indicating flue gas thermometer, a draft gage and a CO_2 recorder.

Figure 3 is an isometric drawing of the main and auxiliary steam piping, and illustrates the unit system employed. Saturated steam is taken from the tops of

the boilers and delivered to the superheaters through an 8-in. line. After being superheated about 150 deg. F., it is carried through 8-in. leads, two of which from each battery are united by means of a Y connecting with a 10-in. branch joining a tie header of like size. This is located in the basement and as indicated delivers the steam through 8-in. leads to the generating units, separators being, however, interposed in these leads as a safeguard to prevent water reaching the turbine. It is thus apparent that, while ordinarily each turbine is supplied with steam from its individual bank of boilers, the interconnecting 10-in. header provides for the supply of steam to either turbine from any one or all of the boilers.

The auxiliaries take steam from an independent system of distribution. Tying in with the 10-in. header is a loop of 4-in. piping so valved that steam may be obtained from either one or both banks of boilers. A continuation of the 4-in. line is carried over into the boiler room to feed an auxiliary header of the same size used to serve the stoker engines and the forced-draft turbines. The other side of the loop feeds branches leading into the turbine room for supplying steam to the condenser, boiler feed and air pump and in order to insure continuity of service many of these lines are in duplicate.

Generating Units

In the turbine room, occupying the east half of the building, are the generating units with condensers and auxiliary apparatus located in the basement below. The arrangement employed is well illustrated in Figs. 2 and 4. While three turbine sets rated at 500, 2500 and 5000 kw., at 80 per cent power factor respectively, have been installed, but two, the 2500 and 5000-kw. sets, are in active service, the other being maintained merely as a reserve unit. Each of the working machines is of the 3-phase, 60-cycle, 2300-v. type and is operated condensing, the larger being provided with an 8000-sq. ft. surface condenser and the other with a jet condenser fitted with radio jet air pumps. Under normal conditions of operation, the 5000-kw. turbine has a steam consumption of about 14 lb. per kilowatt-hour at 300 kv.a, and 13.2 lb. per kilowatt-hour at full load, while the 2500-kw. turbine consumes approximately 14.5 lb. of steam per kilowatt-hour at rated capacity.

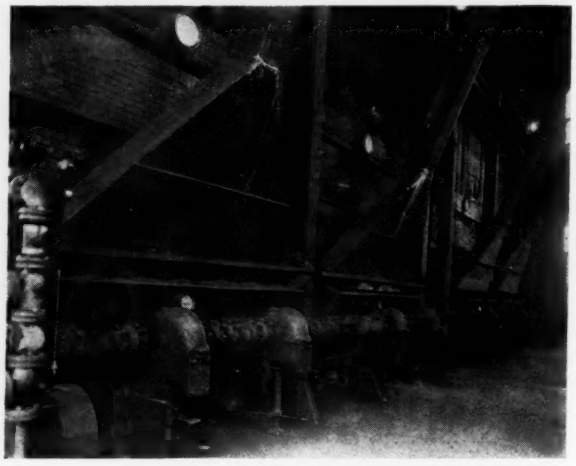


FIG. 5. GENERAL VIEW OF BOILER ROOM

Two 100-kw., direct-current machines provide the necessary excitation for the fields of the alternators: one of these is engine-driven, while the other, the more generally used, is direct connected to a 3-phase alternating-current motor.

The electrical ends of the prime movers are controlled from the nine-panel black slate switchboard shown in Fig. 7. One of these panels is for the tapping of the generator leads, two are for the control of the exciters, one is a local feeder panel, two are house

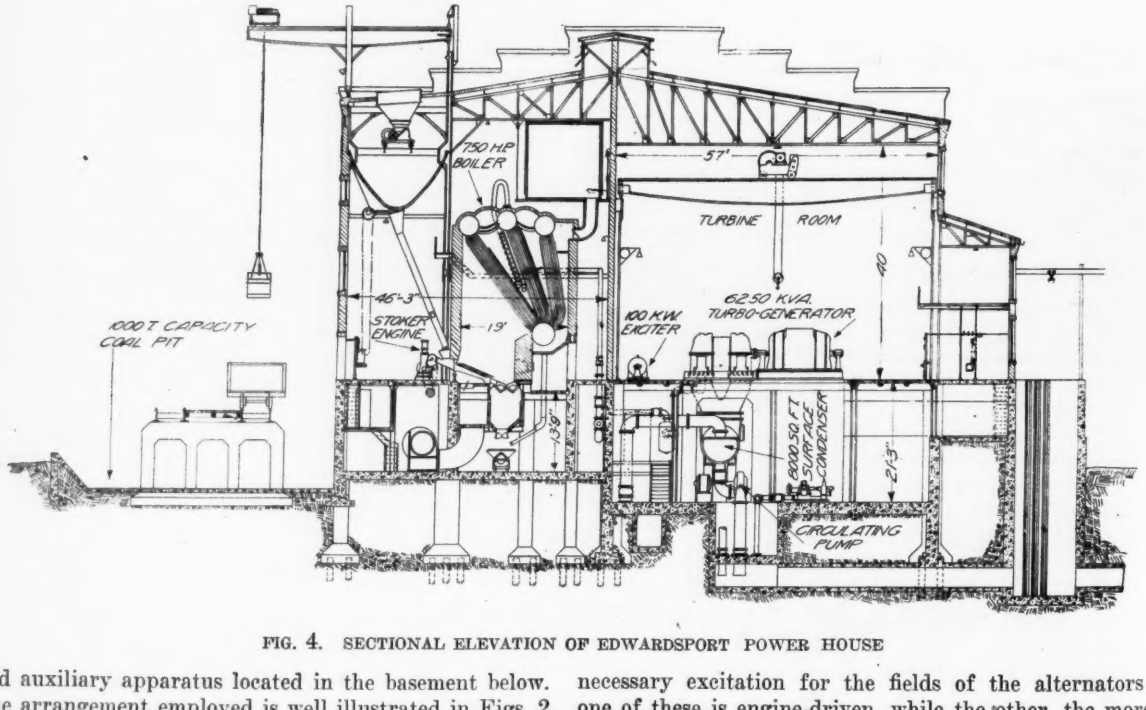


FIG. 4. SECTIONAL ELEVATION OF EDWARDSPORT POWER HOUSE

service panels, one a tap panel and one a Tirrill regulator panel; the other is at present blank, but will be utilized as soon as additional units are installed.

Only 2300-v. currents are handled within the station. Outside on a concrete platform are the step-up transformers which feed the 33,000-v. transmission lines and the high-voltage switches and the electrolytic lightning arresters. The present transformer installation consists of two three-unit banks. The larger of these are rated at 2000 kv.a., 2300-33,000 v. each, while the smaller are of 1000 kv.a. capacity, also stepping up from 2300 and 33,000 v.; the larger units are water-cooled and oil-insulated.

House Service

Practically all of the electric motors used for the operation of station equipment, such as the coal hoist, crusher, turbine room crane, exciter, etc., are of the 3-phase, 220-v. type, and are supplied with power through a bank of three 30-kv.a., 2300-220-v. transformers. The lighting load is carried by a single 20-kv.a., 2300-110-v. transformer.

Meeting Increased Demands

Although the Edwardsport power house has been in operation but a few months, the demand for light and power in the territory served has so exceeded the expectations of the company that the necessity for increased generating capacity was early realized. Accordingly, plans were at once made and actual work is now in progress on the construction of an addition to the north end of the building which, when complete,

FIG. 7. SWITCHBOARD AND SWITCHING EQUIPMENT

will house equipment such as will more than double the capacity of the station. Two batteries of boilers, each of the water-tube type, rated at 750 hp., and fitted with underfeed stokers, will be installed.

The prime-mover equipment will be increased by two 6250-kv.a., 3-phase, 60-cycle, 2300-v. turbine sets, with the general scheme of piping and electrical distribution similar to that in the existing plant.

All engineering and construction work incident to building the plant and placing it in service was executed by the Utilities Development Corporation, of Chicago, of which Harley L. Clarke is president. All engineering was under the immediate direction of C. W. Humphrey, as consulting engineer to the company.

Don't forget that there must be Push in back of your Ideas to get them over.

The Rise of Lignite

THE development of lignite to solve Great Britain's oil problem has been hastened by coal mining industrial troubles. Deposits of the highest grade lignite at Bovey Tracy and elsewhere in Devonshire will speed the production of crude oil, allowing, apart from the cheap electricity generated from lignite, that fuel can be sold at considerably less than the price of coal. In addition to the motor spirit and paraffin obtainable by distillation, a valuable fuel, particularly suitable for Diesel and similar engines, can also be produced, together with lubricating oil and paraffin wax.

Lignite is reported also to produce Montan wax, now a complete monopoly of Austria and Germany. This wax is used in the production of high-grade boot polishes,

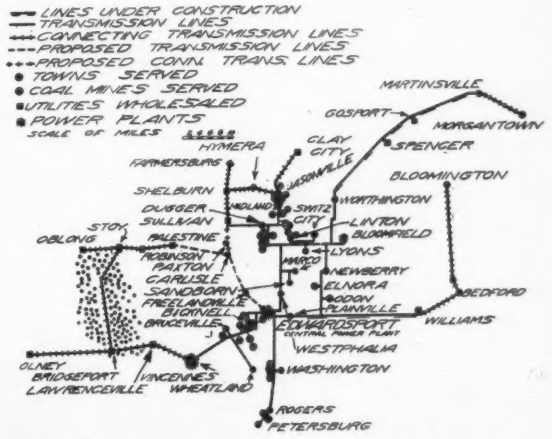


FIG. 8. TERRITORY SERVED BY INDIANA POWER CO.

gramaphone records, etc. One industry in Great Britain is likely to be revolutionized by lignite, and that is the pottery industry, at present centered in Staffordshire in the Five Towns around which the English novelist, Arnold Bennett, has woven so many stories. Cheap coal made possible the growth of the enormous potteries of the Five Towns, but it is believed that the same clay put in lignite-fired kilns in Devonshire at 5 shillings a ton, may result in the establishment of British potteries near cheap clay rather than near cheap coal.

Thus Devonshire would rise—for that is where pottery clay comes from—at the expense of Staffordshire. It is further said that all the towns in South Devon, as well as the industries in the neighborhood, can be supplied electric current generated from Devonshire's lignite deposits.—The Nation's Business.

Get Two Quarts Next Time

The Boss' daughter with several girl friends were being shown around the power house. One of the employes mentioned to the foreman that the big machine was running out of phase. When daughter reached the office, she told Dad that he had better order some phase, that they were about out of it, and she felt mortified to think that somebody was so careless, and all of the girls heard the man tell of the shortage.

I think Dad's smile helped to assuage her.

Handling Condensation---I

METHODS APPLICABLE TO POWER AND HEATING PLANTS. BY CHARLES L. HUBBARD

HOT WATER means heat and heat requires fuel for its generation; hence, every part of the condensation formed about a plant should be saved and returned to the boilers if it can be done at a cost equal to or less than the equivalent amount of fuel which it represents.

The principal sources of condensation in power and heating plants include radiating surfaces of all kind

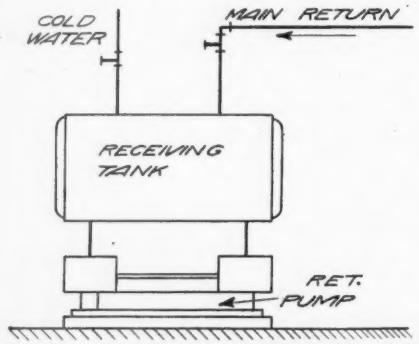


FIG. 1. RECEIVING TANK AND RETURN PUMP ARRANGEMENT WHERE CONDENSATE RETURNS TO TANK BY GRAVITY

used in the heating and ventilating equipment; drips from both high and low-pressure piping; surface condensers; and various machines used in industrial plants, such as driers, slushers, jacketed kettles, tanks heated by coils, paper machines, etc. In the straight power and heating plant, when all or a considerable proportion of the exhaust steam is condensed in the radiators, the return tank serves as a hot-well for the drips for the

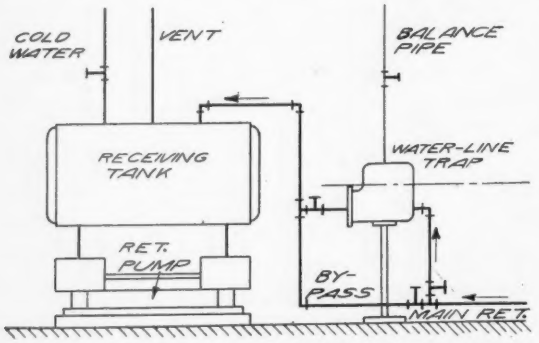


FIG. 2. ARRANGEMENT TO BE EMPLOYED WHERE CONDENSATE MUST BE LIFTED A SHORT DISTANCE

entire plant and is also piped for receiving the fresh make-up water which may be required to replace the oily drips from grease extractors, cylinder cocks, etc., which are commonly discharged to the sewer. In plants of this kind the receiving tank is vented to the atmosphere and the various traps discharge into it. Sometimes the tank is kept under the same pressure as the heating system by connecting the upper part above the water line with a near-by dry return, and any vapor which is liberated from the discharge from high pressure traps simply backs into the heating system through this pipe. There is no objection to this arrangement when the levels are such that all of the condensation will drain into the tank by gravity as shown in Fig. 1, which is usually the case. Sometimes the relative elevations of the tank and return mains are such that it is necessary to lift the condensation a short distance, as in Fig. 2, in which case a vent to the atmosphere will relieve the pressure against which the trap must discharge. This lifting power is slight in a low-pressure heating system, being only about 2 ft. for each pound gage pressure, neglecting friction, so that in practice it is not safe to count on over 18 in. at the most per pound pressure.

In connection with Fig. 2, it may be well to call attention to the use of the water-line trap which is used in this case for sealing the main horizontal returns. In practically all cases, a sealed return will operate more quietly than one with dry or overhead returns where steam and condensation mingle in the same pipe; hence, the main return lines in all large buildings should be

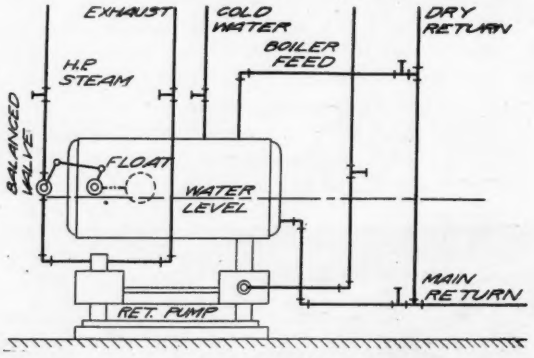


FIG. 3. RETURN PUMP AND RECEIVER MADE TO TAKE THE PLACE OF A WATER-LINE TRAP

sealed to prevent water-hammer and ensure quietness of operation. When overhead returns are used, there is always a slight difference in pressure in the branches coming from different sections of the building which tends to short-circuiting and the backing of steam and water from one return pipe into another, thus producing surging and water-hammer. When the separate branches are brought together under water, and are therefore sealed from one another, this difficulty is eliminated.

A "false" water level may be established at any point desired by means of a water-line trap as indicated in Fig. 2. This consists of an ordinary float trap with the water brought into or near the bottom, while the top is connected with one of the overhead returns of the heating system to equalize or balance the pressures above and below the water in the trap so it will stand at a constant level. With this arrangement, the water in the return system rises to the normal discharge level of the trap and is lifted to the return tank by the steam pressure above it, if the levels are as in Fig. 2, or simply overflows into the tank if the trap is above it.

A return pump and receiver is sometimes made to

take the place of a water-line trap by mounting it at the required elevation and making the connections as shown in Fig. 3. In this case, the tank and its float become in effect a steam trap, and the water is taken by the pump and forced into the boiler instead of being discharged into another tank.

Mention has already been made of the vented receiver, with a pipe leading to the atmosphere. This arrangement is advisable when there are a considerable number of high-pressure traps discharging into the tank. These, should they discharge at one time, would tend to raise the pressure slightly in the tank and so hold back the low-pressure heating returns, at least temporarily, thus unbalancing the pressure in the system of piping and causing water-hammer. By adding a vent pipe to the tank and returning all condensation through traps, any such condition as this is avoided.

In certain plants like large schoolhouses, office buildings, factories, etc., steam is shut off from the radiation at night. When it is turned on again in the morning there is an excessive amount of condensation for a short time until the system gets warmed up, during which

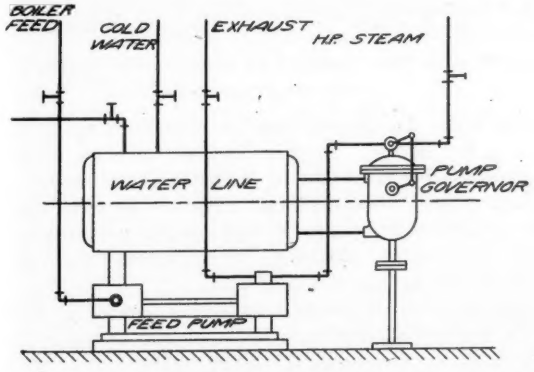


FIG. 4. ARRANGEMENT OF GOVERNOR USED IN CONJUNCTION WITH RETURN PUMP

period a receiving tank of ordinary size will become flooded. In such cases, a receiver of especially large size should be employed, and the return pump may be operated by a special float inside the tank or by a pump governor connected up outside as indicated in Fig. 4.

The interior mechanism of such a device is shown in Fig. 5 and consists of a chamber and float, the latter being so connected by means of levers as to open and close a valve in the steam pipe leading to the return pump, thus starting and stopping it automatically as may be necessary to maintain a constant water level in the tank.

By placing the pump governor at the proper level and making the connections as in Fig. 6, it may be made to take the place of a water-line trap and at the same time operate the return pump automatically as in Fig. 5. The receiving tank simply acts as an overflow reservoir and need not be used in cases where the return of condensation is practically constant at all times, or at least not subject to sudden fluctuations. Another condition which may require the tank shown in Fig. 4, although one of small size may answer, is where there are high-pressure traps discharging into a low-pressure return. If they are connected to discharge into a sealed return, the water, under a higher pressure and temperature, will break into steam as soon as the pressure is reduced, and this steam, as soon as it comes in contact with the cooler water of the low-pressure return,

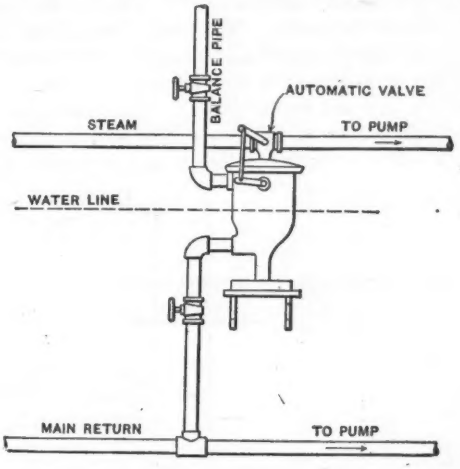


FIG. 5. INTERIOR VIEW OF PUMP GOVERNOR SHOWING OPERATING MECHANISM

condenses suddenly and is likely to cause severe snapping and water-hammer.

By using the arrangement shown in Fig. 6 and discharging into the space above the water, as in Fig. 7, any steam thus formed will pass into the balance pipe and not be condensed so suddenly as to cause trouble

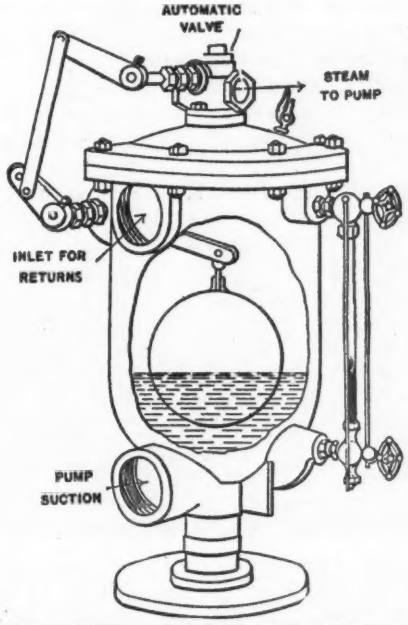


FIG. 6. PUMP GOVERNOR USED TO TAKE PLACE OF WATER LINE TRAP

of any kind. When the heating system is spread out to any extent so as to introduce long runs of horizontal piping, a return-line vacuum system is advisable, as it does away with the necessity of sealed returns, which is often an advantage in cases of this kind. In the case of industrial plants made up of several buildings of large ground area, the matter of grading the returns

is a serious obstacle, and this is entirely eliminated by putting a suction on the main return pipe in the boiler room. This system is especially adapted to plants which have been enlarged from time to time and the pipe lines extended without increasing the size of the original mains nearer the boiler. This results in a drop in pressure in the supplies and a choking of the returns which interferes seriously with the circulation unless a partial vacuum is applied to the return. Only enough vacuum should be carried to bring about a prompt removal of air and water from the radiators and to lower the pressure in the heating system to approximately that of the atmosphere, or at most that which would act as back pressure on the engine, were it exhausting outboard under average conditions. A high vacuum tends to produce a leakage of steam through the automatic return valves into the return main and also to cause a part of the condensation to flush into steam when the difference in pressure between the radiator and return pipe is too great.

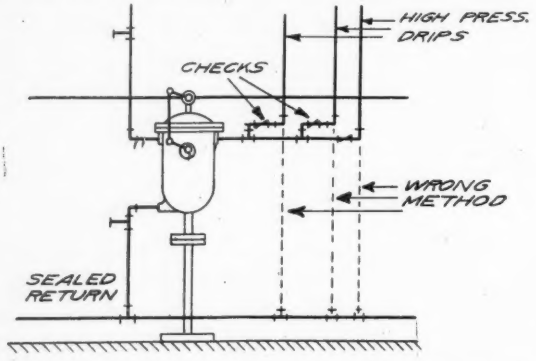


FIG. 7. WITH THIS SCHEME ANY STEAM FORMED WILL PASS INTO BALANCE PIPE AND NOT CONDENSE SO AS TO CAUSE TROUBLE

Ordinarily a vacuum of about 2 in. is carried at the most distant radiator. This may require a vacuum ranging from 3 or 4 to 20 in. at the pump, depending upon the lift and length of run. Under average conditions, however, this will not exceed 8 or 10 in., although sufficient pump capacity should, in general, be provided for a 20-in. vacuum. Typical pump connections for a vacuum system of this kind are shown in Fig. 8. This equipment includes a strainer in the main return, with cold water jet, a controller for regulating the speed of the pump to maintain a constant vacuum of the desired strength, and gages for indicating the supply and return pressures in the heating system. When a closed feed-water heater is used, the vacuum pump discharges into an ordinary receiving tank connected with an automatic return pump. Make-up water is admitted to the tank through a special connection with the city main or other source of supply and pumped into the boilers with the return. In cases where practically all of the exhaust is condensed in the heating system, the amount of make-up water required will be very small and may often be taken care of by the water jet in the suction of the vacuum pump. When an open feed-water heater is employed, taking the place of the usual receiving tank, the air must be removed from the water discharged from the vacuum pump before it enters the heater. In this case, the mixture of air and condensation must first be discharged into a separating tank placed at a sufficient elevation to return the water to the heater by gravity against the pressure carried in the heating system. An arrangement of this kind is shown in diagram in Fig. 9.

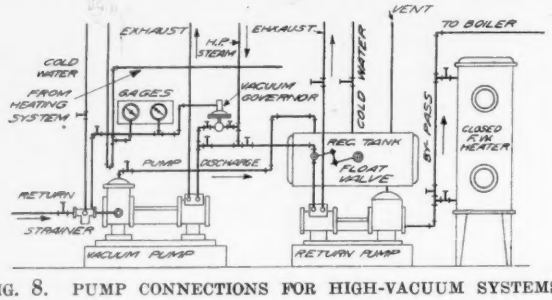


FIG. 8. PUMP CONNECTIONS FOR HIGH-VACUUM SYSTEMS

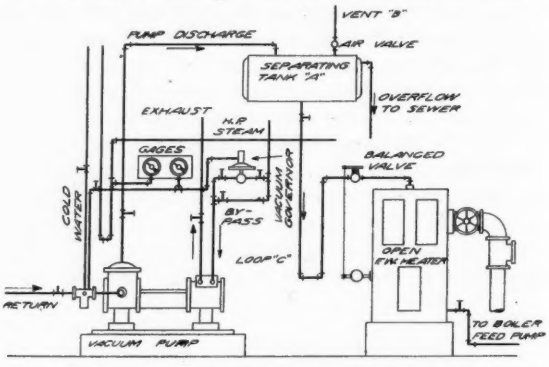


FIG. 9. HEATING SYSTEM AND FEED-WATER HEATER CONNECTIONS

Separation of the air and water takes place in tank A, the former passing out through vent B while the water flows to the heater by gravity through loop or seal C. The height of the separating tank above the connection of the heater (D) should be at least 18 in. for each pound gage pressure carried in the heater, to overcome both resistance and friction and return the water promptly and continuously to the heater.

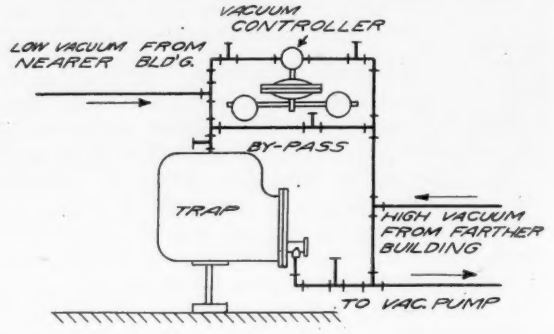


FIG. 10. ARRANGEMENT EMPLOYED TO EQUALIZE PRESSURE IN RETURN LINES

Sometimes the arrangement of the plant is such that the radiation occurs in two or more widely separated groups, and the returns from different buildings are connected with a single vacuum pump in the power house. It is evident, in cases of this kind, that the buildings nearer the pump will have a considerably

higher vacuum unless means are taken to equalize the pressures in the different return lines. This may be done by the arrangement shown in Fig. 10, which reduces the vacuum in the nearest group and traps the condensation from it into the higher vacuum line from the more distant one.

The method of running the supply and return piping for a system of vacuum heating of this kind does not differ from the ordinary gravity system, except that the radiators and coils must always have a double connection. Another advantage, not yet mentioned, is the ability to lift the condensation a certain height, thus making it possible to carry the return pipe overhead, a condition sometimes of considerable importance.

Montenegro's Water Power

MUCH POSSIBLE WATER POWER IS WASTED IN THIS LITTLE MOUNTAINOUS COUNTRY THROUGH LACK OF DEVELOPMENT

THE MOUNTAINS of Montenegro, which have hemmed in that little Balkan country in snug inaccessibility, shutting it away from the rush and advancement of the busy Western World, may be the means of awakening its industrial and commercial life and of lifting it to a more active place in the concert of nations. For, within the bosom of its hills, there arise many swift streams with potential hydroelectric power to make engines whir and wheels spin. Montenegro, hitherto a land of small, rudely tilled fields and herds of sheep and goats grazing on the mountain-sides, might become a thriving industrial country, especially for lumbers mills and woolen mills, if its wasted water power were developed.

This country's name means "'Black Mountain," and

FIG. 1. A TYPICAL SCENE IN MONTENEGRO. PHOTO BY AMERICAN RED CROSS

so it seemed to the first workers of the American Red Cross who landed at its Adriatic port. When they arrived at Teodo, on Cattaro Bay, someone pointed over the gigantic mountain wall and said, "Back there lies Montenegro." There was no railways leading to the interior of the country, and to think of climbing that steep, trackless grade with motor trucks seemed a hopeless undertaking; but it was accomplished. American motors, plus American grit in the Red Cross personnel, turned the trick. Over that impregnable ridge of granite, a ceaseless procession of heavily loaded trucks carried their precious gifts of food, clothes, medicines and surgical dressings to the Montenegrin homes which war and epidemics had ravaged.

Nearly completed is the relief work of the American Red Cross in Montenegro; but its influence will be permanent. These people have been aroused and have become interested in newer ways of accomplishing their daily work. American efficiency, organization and speed are among the heritages that have been bequeathed to it. The slow-moving ox-cart and the mule-pack will no longer satisfy enterprising men who have witnessed the trains of motor trucks that have thundered over the mountains. Neither will candles nor kerosene lamps give

FIG. 2. THE CITY OF PODGORITZA HAS BUT ONE OLD STONE FLOUR MILL, BUT NO ELECTRIC LIGHT PLANT. PHOTO BY AMERICAN RED CROSS

sufficient light for their stores and homes when they learn more of the possibilities of the electric dynamo.

An American business man, recently returned from Red Cross relief work in Montenegro, said that the development of the natural resources of water power constituted the greatest field for American investment. City officials are educated and alert to their country's needs and opportunities, but they do not know how to go ahead

with original projects of building and development. At Podgoritza, he said, there are exceptional opportunities for American enterprise and capital. This city has abundant water power, furnished by two branches of a river, and yet it has no electric lighting plant. Kerosene lamps are the only chandeliers known to this community. An old stone flour mill, whose wheel has been grinding coarse flour for many generations, is the only factory standing on the banks of this stream. In a small room, at the side, an old man stands beside a small hand loom weaving heavy woolen cloth. With the proper utilization of the water power here, modern flour mills and woolen mills, employing many persons, could be erected and managed with financial profit.

Exceptional opportunities are offered for the installation of electric lighting plants. They are few in number in the Balkans at present. Cettinje has the only electric lights in Montenegro, the plants for the neighboring countries being located at Sarajevo and Mostar in Herzogovina, and at Teodo and Cattaro on the Dalmatian coast. These plants are driven by water power, but Ragusa, Dalmatia, has a light plant and a street railway system that are run by coal. Montenegrins like the American nation and would give a friendly reception to American business men or financiers who would aid in the exploitation of the natural water power resources with which this country has been blessed.

Asbestos

By Oliver Bowles

AN ASBESTOS claim has recently been located in Apache County, Arizona. The deposit is said to be extensive, having been traced over 20 mi. Vein exposures are so prominent that, according to report, one can, without the aid of miner's tools, pick up a ton or more of crude asbestos that has broken down from the exposures. Material from the deposit, examined at the United States Bureau of Mines, is of the typical Arizona type. It is strong, flexible, silky, and occurs in cross-fiber veins with a fiber length of 1 to 1¼ in., while fiber 2½ in. in length has been reported. The material submitted shows the effects of surface weathering, and asbestos of better quality could probably be obtained by development work.

The deposit occurs on an Indian Reservation, and unfortunately the present law does not permit the development of asbestos deposits on unallotted Indian lands. The Office of Indian Affairs, through the Secretary of the Interior, recommended that authority be granted to develop unallotted Indian lands for the purpose of mining asbestos, coal, oil, and gas, as well as metalliferous minerals, but favorable action was not taken thereon by Congress. In view of the present shortage of crude asbestos fiber, it is to be regretted that mining work cannot be undertaken on deposits such as that described above.

Conditions in South Africa

A communication from the Assistant Director of the Geological Survey of South Africa conveys the information that America is at present the principal buyer of South African "Amosite." This type of fiber, which is commonly 6 in. in length, has aroused considerable interest among asbestos manufacturers. Some of it is shipped as long fiber, but certain manufacturers prefer to have it cut into material of 1 in. length. The purpose is evidently to adapt it to carding and spinning machinery now in use. It would seem that the superior product obtainable from the long fiber would justify such a modification of machinery as would be necessary for successful spinning of full length fiber.

Regarding production, it is reported that the Egnep and Amosa Syndicate mines are in good condition and large quantities of amosite are available. Prospective purchasers are advised that Mr. Lundquist, United States Trade Commissioner at Port Elizabeth, South Africa, has been supplied with complete commercial exhibits of amosite and crocidolite. Samples of amosite may be examined at the Bureau of Mines, Washington, D. C.

Asbestos Pipe and Wall Tile

An Italian firm owns the patent and has lately begun the manufacture of a new asbestos product. The company is already well known through operation of a very large asbestos shingle plant. The new enterprise is the manufacture of asbestos pipes made of 85 per cent Portland cement and 15 per cent asbestos fiber of shingle stock grade. The pipe is made in various sizes from 4 to 12 in. in diameter, and in lengths up to 12 ft. The thickness increases with the size from about ½ in. for the 4-in. pipe to about 15/16 in. for the 12-in. size. It is reported that four machines are now being operated, each machine having a capacity of 3000 ft. of pipe in 24 hr. The pipe is seasoned under water for 90 days before it is used. It is much lighter in weight than iron pipe, is said to bear a maximum pressure of 450 lb. per sq. in., and to be acid proof and corrosive proof. Even with the high cost of Portland cement in Italy, due to the excessively high price of coal, it is claimed that the cost of manufacture of the asbestos pipe is not more than one-third of the net selling price of English iron pipe. It would seem that pipe having such qualities, combined with a low production cost, could be used to advantage for many purposes, such as for pipe lines or around oil refineries. The company has also begun the manufacture of wall tile similar in composition to the pipe described above. The tile are decorated with imitation rock surface patterns and figured designs, and are finished with a dull glaze. While a better glaze is to be desired, the material is attractive, is less brittle than porcelain tile, and the cost of manufacture is not high. It, therefore, offers a very promising field for development.—U. S. Bureau of Mines, Reports of Investigations.

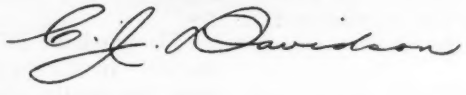
U. S. Civil Service Commission announces an examination for electrical draftsman, to fill vacancies in the Office of Chief of Engineers, War Department, Washington, D. C., and in positions requiring similar qualifications, at salaries ranging from $1200 to $2400. In the absence of further notice, applications for this examination will be received by the Commission at Washington, D. C., until the hour of closing business on July 1, 1920. If sufficient eligibles are obtained, the receipt of applications may be closed before that date, of which due notice will be given. Apply for Form 1312.

CHARLES J. DAVIDSON

WITH THE RAILROAD YARD AS HIS PLAYGROUND AND THE POWER PLANT FOR HIS SCHOOL, A MINNESOTA BOY DEVELOPED HIS CAPACITY FOR BIG ENGINEERING WORK. BY WALTER PAINTER

SOME twenty years ago, a young engineer who had designed a large power plant submitted the plans to the late Edwin Reynolds for criticism. Mr. Reynolds approved and complimented the work and then added: "Young man, remember that while a good set of plans is important, good execution is much more important."

This young man was C. J. Davidson, and he frequently tells of the helpful influence that this bit of advice had upon his engineering career; for Mr. Davidson is one of those chaps who has had to master many handicaps in preparing himself for engineering work.



Up in the town of Lonesborough, Minnesota, when Mr. Davidson was born in 1867, his father worked as a shoemaker. He made good shoes, but health failed and the father died when the son was but four years old. Young Davidson, as he grew up, decided that he wanted to be an engineer, but was unable to have the university training that he eagerly desired. Earning money for his mother's support and his own needs had to come first—his learning came second; but the way in which he advanced himself is proof of his earnestness of purpose.

But let Mr. Davidson tell of his early days:

"It wasn't a promising start for a boy who hoped for a professional career. But I had one good adviser. When I talked with my uncle about my desire to be an engineer, he said to me: 'It doesn't matter so much what you decide to do, but do it better than anyone else.' And I have tried not to let a day pass without remembering his injunction and striving for the goal he set me.

"In securing my early technical knowledge, I bought all the books recommended for which I could find money to pay. These I did not merely read, but studied carefully. Then I went to school whenever I had the chance, especially night school. I took correspondence courses and later employed private teachers. My boyhood playing was usually done in some shop, engine room or railroad yard. I made friends with every locomotive engineer and fireman that I could, and was often permitted to handle a locomotive throttle when I was only 13 yr. old.

"When I was seventeen, I ran an engine for about one year. At eighteen I was employed under the master mechanic in a large oil mill in Sioux City, Iowa. He was a very skillful mechanic and gave me some excellent practical training.

"After about two years, I went with a packing company in the same city as head fireman. Here I had more valuable training under a chief engineer, who, as I look back over his work, was not much of an engineer, but was really a wonderful mechanic. Like many Welshmen, he was a man of strong prejudice, and as I was fortunate enough to be a favorite, I received more instruction than the apprentice in our shops commonly gets. At twenty-three, I was made chief engineer of this plant, my friend having surrendered to John Barleycorn."

About four years later the packing plant passed into a new ownership and, having no ties, Mr. Davidson concluded to go west, but first he went to Omaha to visit some friends who were building a bridge across the Missouri River, and was induced to join their organization. Here he acquired a new line of engineering experience which later proved to be of great value. About the time the bridge work was finished, he accepted the position of chief engineer of the Sioux City Traction Co., which he held until 1898, when he went to Milwaukee as chief engineer of power plants for the Milwaukee Electric Railway and Light Co. This position included much work outside the City of Milwaukee; among other things, the design and supervision of the building of the Ashley Street Plant of the Union Elec-

tric Light & Power Co. in St. Louis, a steam and hydro plant at Appleton, Wis.; a hydro-plant at Watertown, Wis., and the building of the Public Service Building and Commerce Street Plants in Milwaukee.

During this period, Mr. Davidson was made general superintendent of the Milwaukee Central Heating Co., constructing about 10 mi. of street mains in the city streets. This included about 2 mi. of tunnels, including one river tunnel for a cable crossing. In 1911 he resigned this position to engage in engineering practice in Chicago with the corporation now known as the Woodmansee-Davidson Engineering Co.

While in Sioux City, Mr. Davidson was an active member of Sioux City N. A. S. E., having served twice as president. He was later one of the incorporators of the Milwaukee Engineering Society and acted as president. He is also a member of the A. S. M. E., in which he has served as manager, and an associate member of American Society Naval Engineers, member of the Engineers Club of New York and the Engineers Club of Chicago.

Plant Inspection

By H. W. Rose

Start at the bottom of your end of the business, and recheck each and every branch and detail of your power manufacturing institution. Begin from a glance at your stacks; if they never roll any smoke from them at intervals of a minute or two occasionally, you may be sure of the fact that too much air is entering the furnaces, which consumes just as much additional fuel as if they were continuously rolling a black, inky smoke. If nothing is wrong there, an inspection of your furnace settings, stack temperatures, and oil burners if you may happen to be operating them may throw some light upon some trouble which leads to a financial loss not observed by you before. If so far your inspection proves satisfactory, turn your attention possibly to the external conditions of your boilers as to their settings being tight and properly insulated and next, and most important of all, see that you have no hard scale in your tubes regardless of what the thickness may be. If it is only 1/32 in. in thickness upon tubes and shells, you are wasting fuel in a moderate way, and if 1/16 in. or over you are extravagantly doing so.

To cap the matter off, seriously subjecting a boiler to destructive temperatures and all conditions of this nature only lead your operating and maintenance expense account up into higher figures in boiler repair bills such as new tubes, patches, and sometimes new sheets in the shells of your boilers which figures are not so very pleasant to look at, at the close of a fiscal year, unless you have had mighty good luck in other parts of the plant to overcome this account.

If good, so far, notice your boilers in operation, and observe the running water level in your gage glass of the water column. If your boiler feed pumps are equipped with automatic regulators, see that they are set for 1½ to 2 gages of water. Turn your attention to your feed-water heaters, and remember that heat taken from waste steam and stored in your feed-water before it enters the boilers saves coal or fuel oil. Examine your heaters closely, see that they are properly cared for with the proper attention at all times. Remember that the lubricating oil that works through with the exhaust steam, if it is an open heater, mixes with your feed-water, and if your heater is not working mechanically correctly, this oil is carried by your feed pumps into the boilers and there finds its way around the tubes and shell which, in some instances, is more disastrous than scale, and see that your feed-water is leaving the heater at from 208 to 210 deg. F. Glance over your boiler feed pumps, and see that they are all operating correctly as to the stroke of each piston. See that all steam lines throughout the entire room are covered with a good grade of pipe covering, say 85 per cent magnesia, and that valve stems are neatly packed with no appearance of steam blowing by. Next go to the engine room. Engines, regardless of their design, should be operating as economically as possible, and that means not only tight intake and outlet valves and seats, tight pistons and rings with everything being in correct line as to the moving parts, but also all steam should be equally balanced upon both sides of the piston, if not we will acquire a very severe loss of steam.

Your electrical system, bear in mind, is no problem to be casually glanced over, for as great leakage occurs there as in any other portion of the power plant. If a generator is giving you trouble, test it out piece by piece; locate your trouble and then correct it, and your switchboard transformers and main line wiring to all points of conveyance should be free from all groundage and leakage with the proper insulation on the wires. A naked electric light wire is dangerous.

Making, Spending, Saving

A young man on his way to buy a suit of clothes asked a friend to help him pick it out. Everything was satisfactorily arranged, the selection made, and then the purchaser offered the dealer the cash. The friend stopped him and said: "You must not do that. Charge it and pay promptly, say on the first."

"Why should I do that?"

"That's the only way you'll ever become known. The Mercantile Agency will book you as 'good pay,' etc."

The purchaser followed the friend's advice. He paid the bill thirty days later, but admitted that he bought more during that time at the same store, spent more for foolishness, and saved less than he had ever done before in the same length of time.

The young man's experience is the same as many others who have tried the charge account system. The moral is, "pay as you go," and buy only those articles that you actually need. It is not how much you make, but how much you save. While preparing for the rainy day, have some pleasure in fair weather, recalling the words of the immortal poet, Tom Moore:

"As you journey through life, live by the way."

Summing it all up: Don't be a hog either way.

Italy will require this year 12,000,000 tons of coal and 4,000,000 tons of oil. The Italians are moving toward the change from coal to oil in railroad and factory use.—Chicago Commerce.

Fluctuation in Coal Production*

THEIR EXTENT AND CAUSES. BY GEORGE OTIS SMITH AND F. G. TRYON, U. S. GEOLOGICAL SURVEY

AN ELECTRICAL engineer has supplied us with the phrase that best expresses what's wrong with our coal industry—it is the "bad load factor." Whether we refer to full rated capacity or to average output, the operation of the soft-coal mines of the country from year to year, from month to month, and from day to day presents a load factor that has been too wasteful of plant and labor and too productive of high costs and uncertain supply. Engineering is needed to determine first how bad the load factor actually is in this basic industry and next how that load factor can be bettered; and with both inquiries there must be combined publicity of a high order.

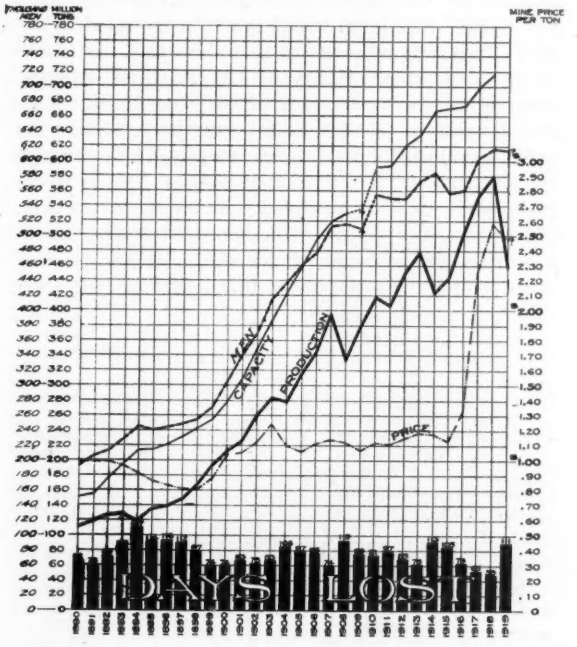


FIG. 1. VARIATION IN IMPORTANT COAL MINING CONDITIONS DURING THE PAST 30 YR.

The fluctuations in coal production can be regarded as annual, which in a large way reflect nation-wide business conditions; as seasonal, which express conditions of market and distribution; and as daily, which express conditions of labor and car supply. An analysis of this ever-changing rate of output of coal can well begin with a long-range view of the variation through a period of years. In Fig. 1, the facts of coal production, labor supply, mine capacity, and average return to the industry per ton produced, are set forth in curves for the 30-yr. period 1890-1919. At the base of the diagram is a graphic statement of lost time in mine operation, which is the measure of wasted opportunity for the economic use of both plant and labor.

First of all, we must remember that the statistics thus presented are weighted averages for a great industry spread over a large country and carried on under conditions that are widely divergent from place to place; these are the facts from the national point of view. Locally the conditions were far better or even worse; yet an exhibit of the trend of the bituminous coal industry as a whole must necessarily precede any detailed discussion. During the past 30 yr. the growth of the industry has been from an output in 1890 of 111,000,000 tons, from mines whose aggregate capacity was estimated at 152,000,000 tons and which employed 192,000 men, to the top figures of 1918, when the output was

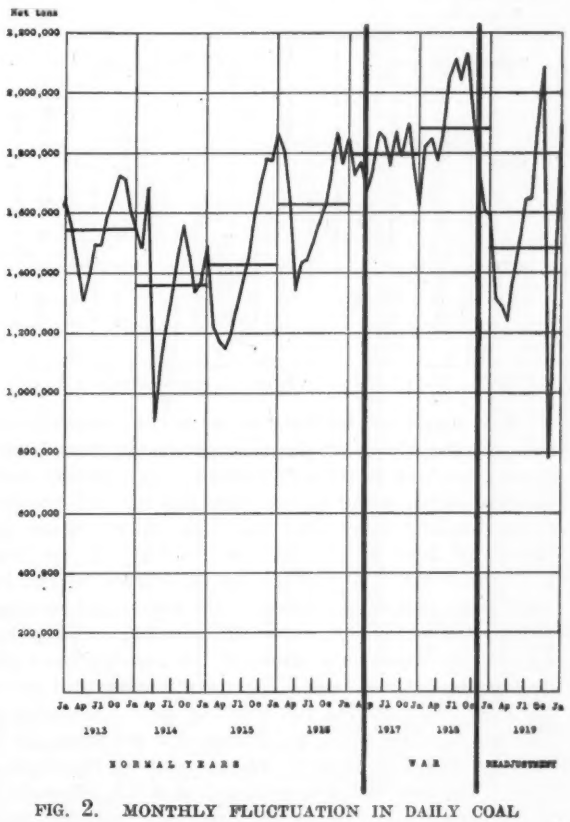


FIG. 2. MONTHLY FLUCTUATION IN DAILY COAL PRODUCTION

579,000,000 tons, the mine capacity was probably 715,000,000 tons, and the mine workers numbered 615,000.

A few only of the outstanding facts may be pointed out in the preliminary study of these figures. First of all, the coal curve shows more frequent and greater fluctuation than the man curve. The general trend, however, of both these lines, representing coal output and labor employed, has been steeply upward, and the curves have fortunately converged, indicating the greater productivity of the average mine worker. The production curve definitely marks the years of general business depression, 1894, 1904, 1908, 1911 and 1914.

Mine capacity is seen to have kept well in advance of output, a relation in large part attributable to ever-increasing expenditures in mine equipment, which also

* A contribution to the special program on the Bituminous Coal Industry, American Institute of Mining and Metallurgical Engineers, New York, Feb. 17, 1920.

largely account for the increase in average production per man from 579 tons in 1890 to 942 tons in 1918. That capacity curve, so far above even the emergency output of the war period, suggests strongly that the industry has become overequipped and overmanned.

The curve indicating average price f.o.b. mine seems to show relatively little influence by the other facts set forth in this diagram. Prior to the world war, the only marked deviation from a smooth curve was the 12-cent rise in 1903, which was apparently due to the anthracite strike of the previous year. A similar lag of a year is shown for most of the years of general industrial depression, the employe's curve being a year behind in registering the effect of decreased demand. In other words, the exodus from the mine to other employment is not immediate, but shows itself in the year following the short-time year.

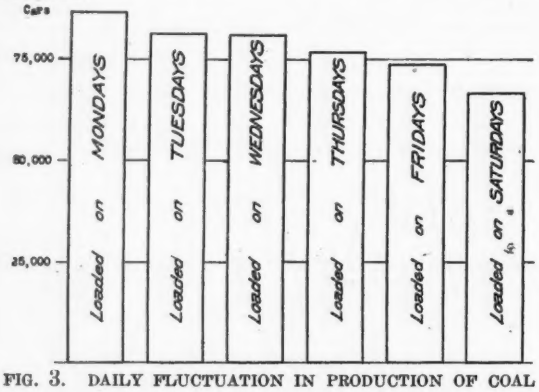


FIG. 3. DAILY FLUCTUATION IN PRODUCTION OF COAL

Most significant for the purpose of the present discussion are the blocks at the base of the diagram, representing lost time in the soft-coal industry. In only seven of these 30 yr. was such lost time less than 25 per cent of the working year. The fact that coal mines are idle for many days in the year is familiar to everybody acquainted with the industry in the United States, but what is not generally realized is the amount of time lost. During the last 30 yr., out of 308 possible working days a year, the bituminous mines of the country were idle, on the average, 93 days. Ten times during that period the time lost exceeded 100 working days. The greatest loss was in 1894 when the average for all mines in the country was 137 days, or 44 per cent of the working year. The smallest loss occurred in 1918, the year of record production, yet even during that year the mines were closed down for one cause or another for the equivalent of 59 days out of 308—nearly one-fifth of the time. These figures for lost time, please remember, show only the days that the mines were not operated, and absenteeism of a part of the force when the mines were running still further reduced the output below that desirable maximum which would be profitable to miners and operators alike; that is, the figures of "average number of days worked and lost" refer to mine operation, but do not necessarily represent the days worked or lost by the average miner. They show only the average opportunity offered to labor by the mines, not the extent to which the individual miner took advantage of his opportunity.

Returning to the consideration of the 30-yr. curves, we may detect some discordance between production and capacity. The inevitable lag in time between development and active exploitation has a decided bearing upon working time. It means that during the initial period of a time of depression the disparity between production and capacity, which is the cause of poor working time, increases rather than diminishes. The diseased industry is thus carried by its own inertia into a condition which further aggravates the disease.

The fact seems established that there are periodic though irregular fluctuations in working time, resulting first from general business depressions and second from simple inequalities of growth during periods of unbroken general prosperity. It remains to attempt an estimate of the magnitude of these causes in restricting working time.

It is noteworthy that with two exceptions none of the annual periods of time lost, as shown by the diagram, has been shorter than 74 days during the 30 yr. covered by the record. The exceptions were the war years, 1917 and 1918, which must be excluded as abnormal. It is also noteworthy that there is a certain regularity about the heights of the columns during the prosperous years. A value of 74-78 occurs seven times, and a value of 82-83 occurs three times. These values point significantly to a figure around 78 or 80 days as the measure of the minimum loss which no ordinary increase in general prosperity is likely to remove. Is not the conclusion justified, then, that losses above this figure are the measure of the effects of annual fluctuations, and that losses below this figure are attributable

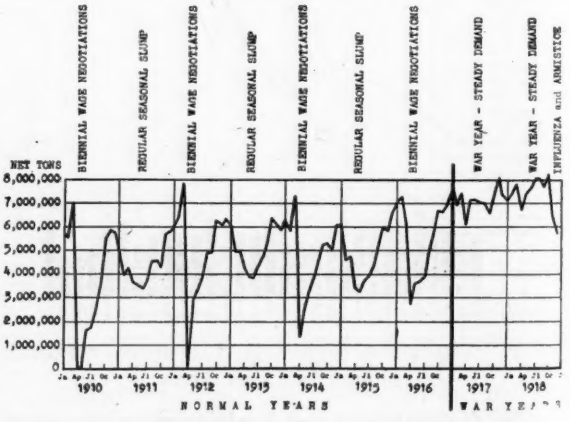


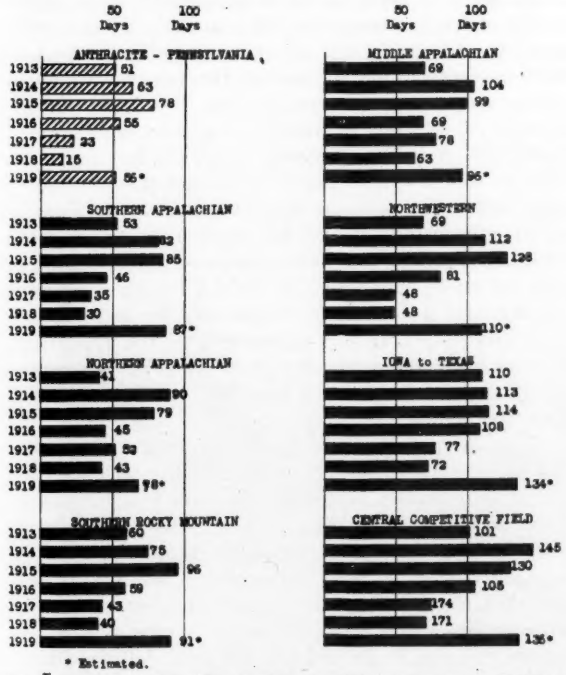
FIG. 4. SEASONAL FLUCTUATION IN DEMAND FOR ILLINOIS COAL

to some other cause? Expressing the idea another way: If we imagine all the columns beheaded at the 78-day line, the sum of the cutoff ends would be the measure of the loss caused by annual fluctuations and the truncated stumps below the 78-day line would be the measure of losses due to other causes, and these may be called the seasonal and daily losses.

This division of lost time means, then, that out of the average loss of 93 days a year, 16 days were due to extraordinary annual fluctuations in demand, chiefly fluctuations following business depression. This amount of annual as distinct from seasonal fluctuation is not confined to the coal industry, and no help can be found for it short of doing away with business cycles of good and bad years.

There remains, however, that residue of lost time from which no normal year is free. This as yet irreducible residue, as already noted, is from 76 to 80 days, and light on its causes must be sought in the study of seasonal fluctuations in the daily rate of production of bituminous coal, by months, from 1913 to 1919, shown in Fig. 2. For convenience the average for each year is shown as a horizontal line. The general trend may be read by comparing the height of these average lines, and this trend, with its sags in 1914-1915 and 1919, is an example of the annual fluctuations which depend on changes in general business conditions. Superimposed upon this big cycle are a set of smaller fluctuations determined by the seasons. For the pre-war years 1913-1916 the seasonal movement is regular and exhibits the familiar summer slump in demand.

In 1917 the war demand obliterated the seasonal slump; the curve of monthly production zigzags now above, now below, the line of the annual average. The year 1918 shows a marked seasonal fluctuation, but in a direction contrary to the rule. Instead of declining from January to April, the curve of production rises without a serious break to a peak in July, August and



* Estimated.

FIG. 5. DAYS LOST PER YEAR, ANTHRACITE AND SEVEN BITUMINOUS REGIONS

September and then falls. In that year the summer stretch of the curve was buoyed up by the extraordinary war demand and by the special measures taken by the Fuel and Railroad Administrations to improve the car supply. Further, the two extremities of the curve were depressed, in the first quarter of the year by bad weather and consequent transportation difficulties, and in the last quarter by the slackening demand. The year is interesting because it gives a type curve of maximum production. Our war experience showed that, given the necessary demand, it is physically possible to push the rate of coal production up during the summer even to a point much in excess of the maximum winter rate.

The 1919 curve is in part true to type, in part exceptional. It exhibits the spring and summer depression, accentuated by the necessary readjustment of business after the armistice. Its October peak was both hastened and steepened by the knowledge that a strike was threatening. The profound collapse of November-December was of course the effect of the great strike.

Even in years of active demand the present inequalities in the summer and winter buying of coal render inevitable a long period in which the labor and capital engaged in the industry can not work more than 27 to 30 hr. out of a 48-hr. week. Let no one regard this as

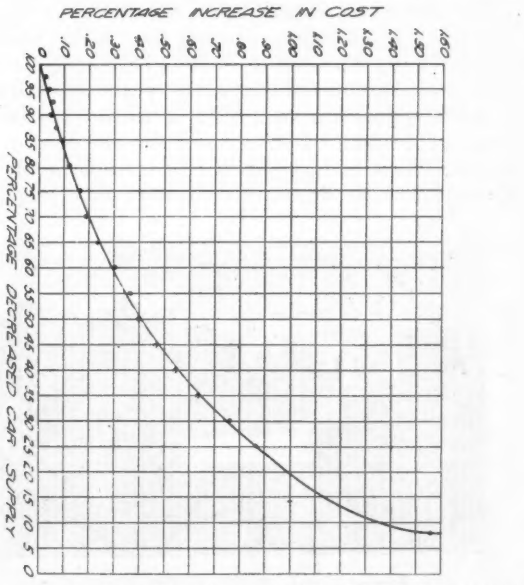


FIG. 6. EFFECT OF IRREGULAR WORKING TIME UPON COSTS

a condition to be accepted as the measure of working time necessary to meet demand. As a matter of fact the 30-hr. week is the spring ailment of the bituminous coal industry, not its cure.

In addition to the annual and seasonal fluctuations in production, a third set of fluctuations is exemplified in Fig. 3. The railroad works seven days a week; the mines work six days. Over Sunday the carrier catches up in its work of placing cars, and in consequence the car supply on Monday is by far the best of the week. As a result the miners work longest on Monday, but later in the week their hours of labor show a gradual decline, which is accentuated on Saturday by holiday absenteeism. Even if the mines should attain full time on Monday they could not under the circumstances expect to work more than 86 per cent of the time on Friday and 79 per cent on Saturday; but of course the Monday rate never in practice gets up to 100 per cent, and the performance on the later days of the week is correspondingly defective.

The data on seasonal fluctuations so far presented apply to the country as a whole. The typical curve production for the United States is, in fact, a composite of a large number of other curves, which differ widely from field to field. Some of these differences are only matters of degree, the curves for some districts showing a more pronounced slump than those for others, but in other cases the curves are unlike and the differences tend to

neutralize one another and so to smooth out the composite curve.

The average for the country thus does not at all reveal the full extent of the disease from which the industry suffers. We have merely charted the average temperature of a number of patients in which the severe chill of one patient is offset by the high fever of another. This all-country curve seems discouraging enough; but it in fact conceals much local trouble, and any remedy that is to better the operating conditions of both the miners and the owners must be applied in terms of local, not national fluctuations. To find this remedy, further study of the district fluctuations is therefore essential.

The curve for Illinois (Fig. 4) illustrates seasonal fluctuation at its worst. During the "odd" years the demand in the slack month sinks to half what it reaches at the peak, and during the "even" years the production in April approaches zero. The causes of the summer slump are twofold. In the first place, the natural market for Illinois coals, as limited by transportation costs, is one in which domestic consumers rely largely on

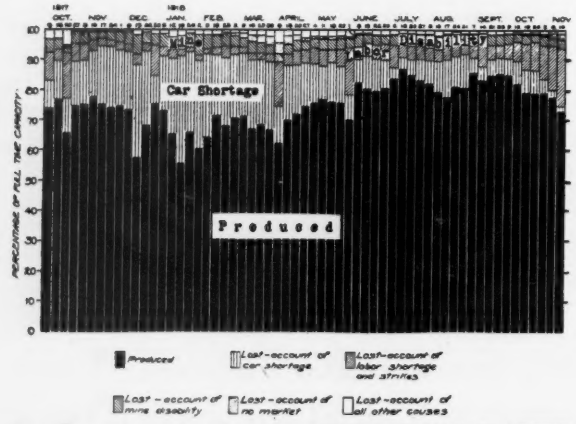

Car Shortage
Produced
PERCENTAGE OF FULL TIME CAPACITY
Produced
Lost - account of car shortage
Lost - account of labor shortage and strikes
Lost - account of mine disability
Lost - account of no market
Lost - account of all other causes

FIG. 7. CAUSES OF LOST TIME WHEN DEMAND IS ACTIVE

bituminous coal, and of all classes of demand that of domestic consumers fluctuates most with the seasons. Into the market, unfortunately, the steadying effects of the Lake and New England movements and of overseas exports do not enter. In the second place, the nature of Illinois coals places them at a disadvantage in competing even within this, their natural market. They do not store easily, and up to the present time they have not found favor with coke makers and therefore do not feel the steadying influence of the demand for coke.

Any industry that offers its labor and its capital employment so irregular as that expressed by the Illinois curve is laboring under a great handicap; yet the Illinois curve is roughly typical of the production for the whole Mississippi Valley region, from Indiana to Iowa and south to Arkansas. Some 175,000 miners and 28 per cent of the mine capacity of the country operate under a curve of this type.

The statement of lost time by districts further emphasizes this regional variation. Figure 5 shows the averages for the seven grand subdivisions of the bituminous fields, to which is added, for comparison, the anthracite region of Pennsylvania. The figures given represent the real losses of potential working time, each day lost meaning a cut in the actual productive capacity of both mine and miner.

During the seven years shown in the diagram, each of the bituminous regions has lost more time than the anthracite country. By regions the 7-yr. average has been as follows, arranged in order of time idle:

Region	Days worked	Days idle
Anthracite	260	48
Southern Appalachian	248	60
Northern Appalachian	247	61
Southern Rocky Mountain	242	66
Middle Appalachian	225	83
Northwestern	223	85
Iowa to Texas	204	104
Central competitive field	199	109

It is perhaps significant that there is a rough relation between the loss of working time and the degree of unionization. Those bituminous regions in which interruptions to operation are most pronounced show a tendency to become union territory. The presence of the union is both cause and effect. Wage disputes cause lost time; but, on the other hand, irregular employment is in itself a prime incentive to unionization.

The fact of irregularity in working time is thus indisputable, and its extent is shown to be everywhere great, and everywhere it reacts unfavorably upon all who have a share in producing soft coal and all who have a share in consuming it. Its injurious effect is perhaps most evident on the welfare of the miner. To him it means a direct and immediate loss of wages. In long periods of idleness following a business depression, it drives him to seek employment elsewhere, in other industries, as was shown in Fig. 1. The fact that we find the same large labor turnover and the tendency to migration in other industries should not blind us to the fact that these are causes as well as symptoms of industrial unrest. The question may even be raised whether irregular employment is not largely responsible for the failure of coal miners to take full advantages of the opportunity to work when the mines are open. Regular employment breeds regular habits and irregular employment breeds irregular habits.

The case of the miner against irregular operation has already been forcibly set before the public. What is not so generally realized is that the case of the operator is just as damaging to him. His capital is idle, and his mine equipment instead of benefiting by a rest, is rapidly depreciating. Although the mine shuts down, his fixed charges run on, not only interest charges and salaries, but a host of maintenance charges as well. And in the end the coal consumer pays the bill for idleness of miner and mine.

In this connection, we may find instruction in an exceedingly valuable study made by Messrs. Garnsey, Allport, and Norris of the costs of production as affected by interruptions of working time. Figure 6 is taken from their "Report of the Engineers' Committee of the United States Fuel Administration, 1918-19." It represents an analysis of the monthly records of 73 operators in the New River district of West Virginia. The diagram shows that there is a mathematical relation between cost of production per ton and decrease in working time. The special cause of irregular working time selected for analysis was car shortage, but any other cause of loss would presumably have affected in the same way the cost per ton. The reason for the increased cost per unit of output is, of course, that the smaller

the number of tons produced the larger the share of the fixed overhead expense which must be borne by each ton. Francis S. Peabody, testifying before the Frelinghuysen committee on Sept. 4, 1919, stated that "the earnings of the laborer and the cost of coal depend entirely upon continuous work. Our costs will vary from month to month, dependent upon the running time of our mines. There will be a variation of between 50 and 60 cents a ton from month to month, depending upon the number of hours the mines are idle."

The effects of fluctuation in coal production on our transportation system can readily be appreciated. The coal mine is the railroad's largest shipper, and the railroad in turn is the largest consumer of coal; in fact, it has been remarked that coal is the nucleus around which our railroad system is built.

A complete analysis of the effects of the irregular operation of the coal mines would include references to the coal dealers, both wholesale and retail; but the consumer is, of course, the one whose purse suffers most, for in the long run he pays for all the wasteful practices. He must support the miner for not only the 215 days that coal is coming from the mines, but also for the 93 possible working days when the mines are closed.

The immediate causes of these seasonal fluctuations are car shortage, labor shortage, mine disability, and "no market." The varying values to be assigned to all these causes are shown in Figs. 7 and 8.

Any statement of the extent and causes of the fluctuations in coal production lacks vision unless it at least faces the search for a remedy. The limits of the statistical summary permit only suggestions, and these, although not novel, are probably worth the attention of everyone who attacks the problem of stabilization. Plainly, fluctuation in production expresses to some extent fluctuation in demand.

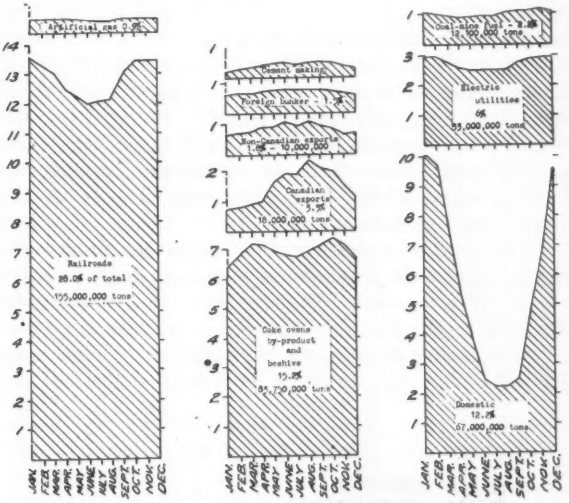


FIG. 9. TYPICAL CURVES OF MONTHLY BITUMINOUS CONSUMPTION

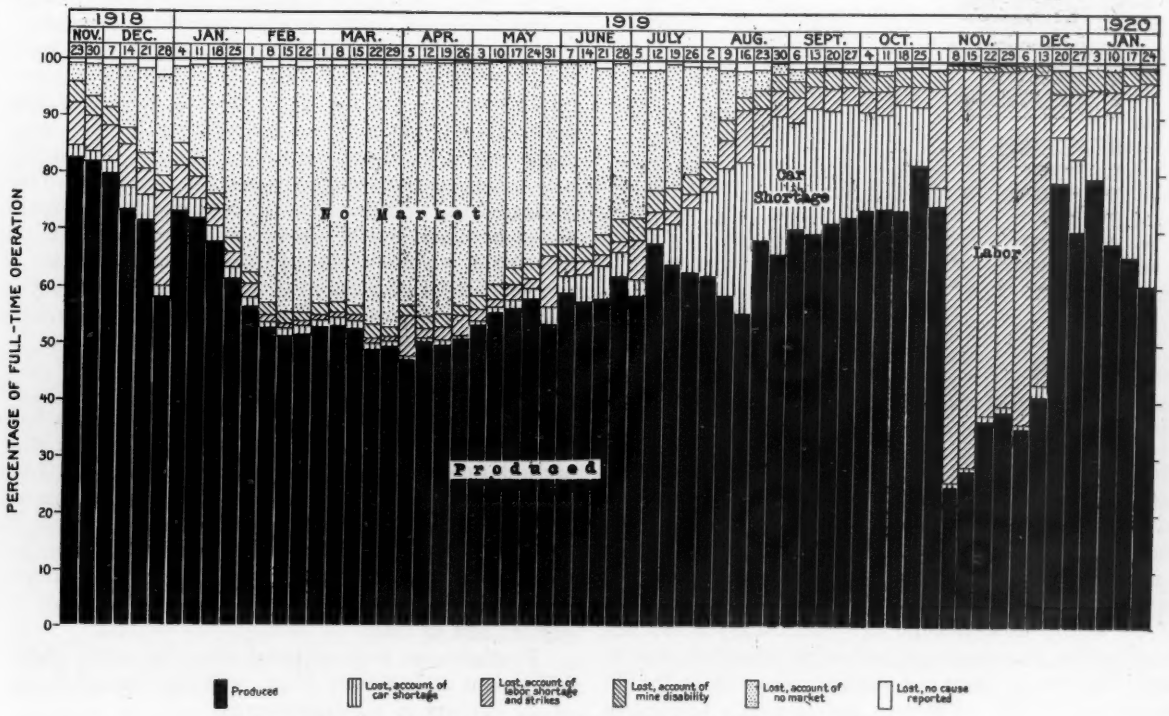


FIG. 8. CAUSES OF LOST TIME WHEN DEMAND IS SLACK

The average number of days lost by reason of strikes for the mines of the whole country, both anthracite and bituminous, during the 9 yr., 1910-1918, was less than 11 per cent of the whole time lost. This is not, of course, a measure of the losses incurred locally in certain years, but it shows that other causes have had wider and more persistent effect upon the working time of the mines.

An attempt to study the degree to which different consumers affect the seasonal market yielded the group of consumption curves given in Fig. 9. The seasonal fluctuation in locomotive consumption is seen to be a factor, for the railroads consume 28 per cent of all soft

coal mined. An even larger offender in degree is the domestic consumer, although the amount involved is much smaller. The general industrial user doubtless ranks next as a contributor to the seasonal fluctuations; but the public utilities present a much more even curve, and the curve for the iron industry is somewhat the same. Fortunately, in certain other industries, such as the cement and clay-products industries, the summer coal consumption exceeds the winter and the effect on the general production curve is beneficial. Export and bunker trade and the Lake shipments likewise tend to smooth out the seasonal curve.

The line of attack for the betterment of seasonal demand therefore seems to be narrowed down to a few classes of consumers. The problem of improving the load factor for the coal mines thus becomes a problem of encouraging the summer buying of coal. Two methods of solving this problem have been suggested: seasonal discounts of the coal price and seasonal freight rates. Both methods seem economically sound and both will doubtless be fully discussed. Figure 10 presents a comparison of lost time in the anthracite and bituminous mines since the summer discount was introduced for anthracite. It will be noted that the present advantage of the anthracite mines did not immediately follow the new system, the consumer has to be educated even to serve his own interests. A seasonal discount in freight rate seems wholly justified by the railroad's interest in its own load-factor; it too can afford to bid for summer traffic in preference to the more expensive winter haul.

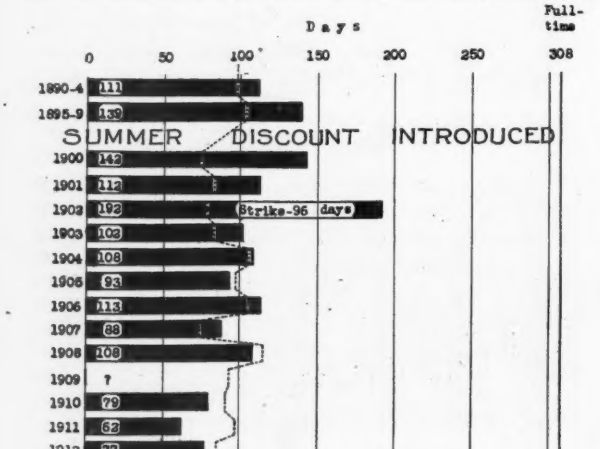


FIG. 10. DAYS LOST IN ANTHRACITE MINING BEFORE AND AFTER THE INTRODUCTION OF SUMMER DISCOUNT

But these or any other methods of increasing summer buying of soft coal cannot be considered apart from the question of storage; to what extent can storage be made practicable and to what extent can it be made attractive to the consumer, large or small?

The general interest of our whole nation in bettering the load factor of the soft coal industry is large. Irregular employment is both a loss in manpower and a cause of social unrest. Society can not view with equanimity the spectacle of an excess mine capacity of 150,000,000 to 200,000,000 tons, and an excess labor force of perhaps 150,000 men.

To stop this industrial leak is the task of the engineer.

Safety in Power Stations

EMPLOYES should be taught that high potential currents are dangerous to life, and they should know the voltage carried by every conductor in their station or under their supervision. They should be instructed that not only the bare conductor, but the insulation as well, on high-voltage conductors should not be touched or closely approached. A wire insulated for and carrying a potential of 110 v. might be, and is, reasonably safe to handle; but the same or similar wire, carrying a potential of 1000 v., although to all appearances perfectly insulated and harmless, would be extremely dangerous to handle, and the higher the voltage the greater danger to life. It cannot be too often repeated or too strongly impressed upon all the employes that insulated, as well as bare, cables or wires carrying high potentials are dangerous to handle or approach, unless they are enclosed with a grounded metal sheath. Insulation on high-tension conductors gives a sense of false security to the uninstructed and many serious accidents to employes have occurred because a conductor was thought to be safe because it was insulated. It is the old story of "didn't know it was loaded." Electric current at high potential will jump from a conductor through some insulation, and it is not necessary to make actual contact with a high-voltage conductor in order to receive a fatal shock. This matter of not placing too much dependence, as far as personal safety is concerned, on the insulating covering of wires is often neglected in the instruction of new men, and it is something that should be thoroughly explained and understood by all operators and linemen. —Electrical Safety Magazine.

IN CONNECTION with the fuel oil situation in New England, it is of interest to note that the Maverick Mills of East Boston, Mass., makers of fine cotton cloth from combed yarns, are installing oil-burning equipment. The plant of the concern has 1600-boiler hp. to equip in the new manner. It will use 30,000 bbl. of fuel oil per annum, in lieu of 7000 tons of coal. It is stated that a 5-yr. fuel oil contract has been closed, at about half the present cost of coal.

Furthermore, it is reported that the entire Pacific Mills plant at Lawrence, Mass., will soon extend the use of oil burners to all departments.

In taking up the problem of sufficient storage capacity for fuel oil, a number of the mills at New Bedford have hit upon the expedient of constructing underground reinforced concrete tanks. The first, and one of the largest in this fine-goods center, has been undertaken by the Beacon Manufacturing Co. It is planned to be oblong in shape, with rounded corners. It will be 50 ft. one way and 60 the other, with a depth of 10 ft., having a capacity of 133,500 gal.—Cotton.

Steel Smokestacks

DETAILS THAT LENGTHEN THE LIFE AND RELIABILITY OF STEEL STACKS FOR POWER PLANTS. BY CHARLES B. RISLEY

THE STEEL smokestack commonly used is often so slighted in design or workmanship in construction that the life of such stacks may be 40 to 60 per cent less than one has a right to expect. It is certainly a great mistake to sacrifice so much of the life of the stack by saving a few dollars in the cost of construction.

Although a stack may have already been constructed, the life of such stack may be prolonged if placed in position with the girth seams outside lap up. Or as a slang expression sometimes used "up end down," as will be shown later.

Except for improper anchoring, there is no doubt that 99 per cent of stack failures are due to the giving way of the girth seams, the cause of which is usually due to the upset end of the rivet becoming eaten away by corrosion until the grip yields to the strain upon it to loosen and rapidly wear away by the swaying of the wind until it can no longer stand up under the strain and the stack falls.

Another weakening of the joint is due to corrosion of the inner plate at the riveted seam allowing the rivet to pull through the weakened sheet. The effect of such corrosion is shown by the heavily shaded portion, Figs. 2 and 3, illustrated herewith.

It is therefore evident that if we may overcome, to some extent, this defect we shall have lengthened the life of the stack accordingly.

To accomplish this, it is first necessary to place the laps of the girth seams so that soot, rain, etc., will not be carried into the lap to corrode the sheets; but instead, the laps should be so arranged that when painting the stack the laps will be filled by paint which runs down the stack, sealing the joint against moisture or corrosive acids. Another advantage of this construction is that the appearance of the stack is not marred by streaks caused by moisture running through the joint from within, therefore the lower end of the upper ring should pass within the upper end of the lower ring as shown, Figs. 1 and 4.

Next, to offset the effect of corrosion of the inner lap, it is important that the drilling of the sheets should allow for greater lap below the rivets of the inner sheet as shown in Fig. 4. An investigation by the writer has shown that the edges of the inner laps corrode worst near the end as shown by the heavy shaded portion, Fig. 4.

For instance, if we have a 2-in. lap on the joint, the outer lap should be drilled 5/8 in. from the edge to center of hole and the inner lap should be drilled 1 3/8 in. from edge to center as shown, Fig. 4. Again, to offset the effect of corrosion on the rivets, it is necessary to use a heavier rivet which may be longer and permit a heavier head driven on without bending the shank in driving.

The upset end of the rivet covers more of the sheet, protecting it from corrosion and adding strength to the joint also by greater frictional compression between the sheets.

Now if a 3/8-in. rivet is calculated to be sufficient for a certain stack when new the writer would advise the use of at least a 1/2-in. rivet.

With this joint construction you have a right to expect possibly 40 per cent longer life from your stack. Figures 3 and 4 show comparative joints of the same size sheets subjected to the same amount of corrosion, Fig. 3 being constructed with a 3/8-in. rivet and Fig. 4 with 1/2-in. rivet. It will be noted that the 3/8-in. rivet is weakened to a point of near failure by corrosion, while the same amount of corrosion on the 1/2-in. riveted joint leaves it sufficiently strong.

The joints may be further protected from corrosion by coating them with a metallic cement or with a compound made of equal parts of asbestos siftings and flour of mica or fine graphite mixed with linseed oil to a consistency of thin paste.

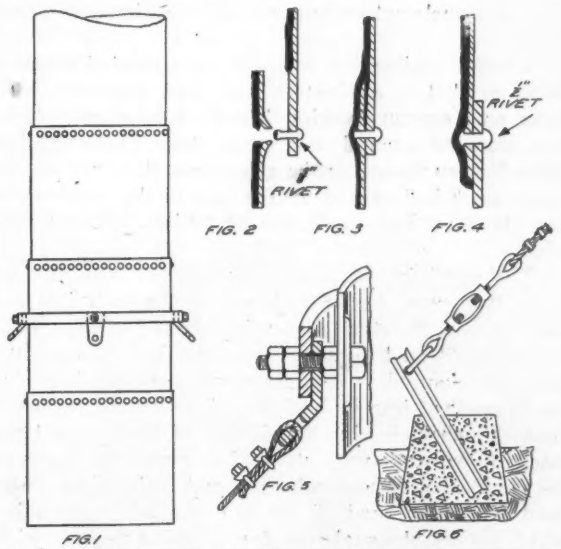


FIG. 1. STEEL STACK SHOWING PLATE ARRANGEMENT AND BAND FOR ATTACHING GUYS

FIG. 2. HOW STACKS FAIL AT THE RIVETS

FIG. 3. NATURE OF STACK CORROSION WHERE UPPER END OF SHEET IS ON THE INSIDE

FIG. 4. NATURE OF CORROSION WHERE UPPER END OF SHEET IS ON THE OUTSIDE

FIG. 5. DETAILS OF BAND FOR ATTACHING GUYS TO STACK

FIG. 6. SUBSTANTIAL ANCHOR POST FOR STACK GUYS

A few years ago, the writer installed a boiler plate in which he specified the stack which was 5 ft. diameter and 130 ft. high made up of sheets 7/32 in. thick, the girth seams were lapped as shown in Fig. 1 with rivets 5/8 in. diameter, pitch of rivets 2 1/2 in. The rivets were driven hot. The interior of the stack was coated with a special cement and the outside was painted with a special stack enamel paint. It was fitted with two sets of guy bands similar to the one illustrated, Figs. 1 and 5, made of flat iron 5/8 by 2 1/2 in.; eight guy wires secured the stack to ground anchors consisting of T rails sets in a concrete pillow as shown in Fig. 6.

The extra cost of the heavier rivets and labor was insignificant as compared with the total cost of the steel sheets.

Another cause for stack losses is due to poorly anchored stacks; one common defect is the use of inadequate eye bolts, turnbuckles, etc., and the manner in which the guy wires are attached.

Some years ago, the writer visited a new plant and noticed one of the steel stacks leaning slightly, whereupon further investigation revealed only one set of guy wires attached by means of a ½-in. eye bolt with the eyes not welded and attached to the stack by simply drilling a hole in the sheet with a nut inside. This stack was about 36 in. diameter and 50 ft. high. The eye had straightened out and was on the verge of falling with a strong wind blowing. The matter was immediately brought to the attention of the manager and a rope was thrown over the guy wires and pulled up around the stack and anchored while permanent repairs were being made.

Another similar case was recently corrected where a 60-in. by 100-ft. smokestack had been anchored with ½-in. open eye turnbuckles. The stack bands were light and clamped around the stack these bands having slipped down loosening the guy wires, the sway of the heavy stack had opened up the eyes in the turnbuckles and the stack was in danger of falling with the first wind.

The guy wires were arranged in two sets of four each; two guys, one of each set, were attached to the same anchor, therefore the tension of the two guys could not be maintained the same, throwing the load upon the guy that chanced to be tightest. The writer had new bands made of iron ⅝ by 3 in., which were 2 in. larger than the stack, leaving a space of an inch around the stack; these bands were attached in a manner as shown in Fig. 5. A plate inside the stack 6 in. square was used under the head of the bolt, the bolt was ⅞ in., which carried the angle lug for attaching the guy wire, also the stack band as shown. Another view of this band is shown in Fig. 1. With a band of this type, the strain upon the stack is not carried by a single bolt as where no band is used; but the stack being firmly bolted at four points, it is rigidly reinforced, making it impossible for the guy pulling out of the stack.

The eight guy wires were spaced at eight equal spaces around the stack and anchored at eight ground anchors instead of four as before, thereby dividing the load equally and more uniformly upon the guy wires.

The ½-in. turnbuckles were replaced with ¾-in. turnbuckles which made a very strong job. The stack bands of this style make it more convenient for the steeple jack to hook his rig and work his rig to the top of the stack from band to band when preparing for painting.

The steeple jack was, however, at a loss to know how to get the bolts and plates as shown at Fig. 5 through the stack which was in service and one could not enter it. This the writer accomplished by tapping a ¼-in. rod, 6 in. long, threaded at one end to screw into the hole tapped in the ⅞-in. bolts and a hole drilled in the other end to which is attached a wire. When the steeple jack had cut a hole in the stack for the bolt the ¼-in. rod attached to the wire is passed through the hole and down the stack to the base. This wire was fished out through the cleanout door and the ⅞-in. bolt with plate was attached and drawn up and into the hole, the ¼-in. rod serving as a handle to lift the bolt in place while the first nut is being screwed in place.

Occasionally angle irons are riveted lengthwise of stacks for reinforcing the joints and may prolong the life of the stack, but with the use of heavier rivets and better joint construction angle bars are not required.

Figure 6 shows a very good ground anchor for stack guying and is sufficiently explanatory.

Steel stacks, especially if mounted on a brick or concrete base and having no metallic contact with the ground, should be provided with a suitable ground conductor, of copper, zinc or galvanized plates buried to a depth of moist earth for the purpose of carrying any lightning currents to the ground, preventing their atmospheric discharge.

A good stack paint is made by compounding fine graphite three parts, Germantown lampblack one part mixed with linseed oil to a working consistency.

Care of Belts

In the March 1 issue of Power Plant Engineering was an article on how to take care of stretch in vertical belts.

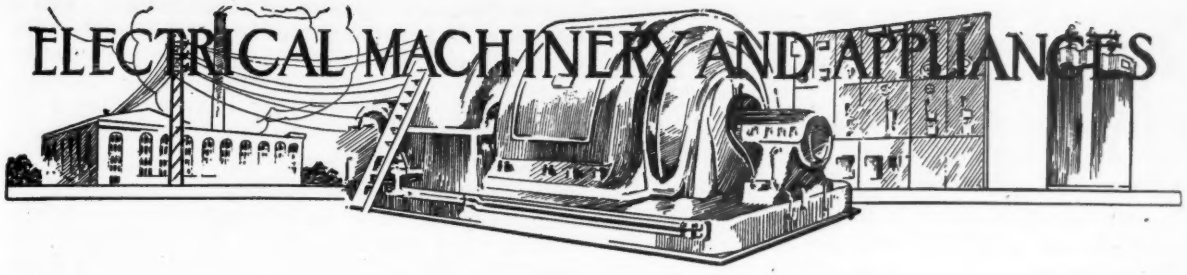
Filler pieces are all right, but where it is possible to put a light, straight-faced, flanged idler pulley on slack side of driving pulley and as near the driving pulley as possible, the belt makes more contact on both pulleys and the belt will run a long time before having to be taken up. It will give less slip and cause much less strain on the bearings.

The frame of the idler can be made out of pipe and for best results ought to hang at an angle of about 45 deg. to the belt run.

M. W. Cartee

At last the corn cob has come into its own. The cob has been relegated to the scrap heap for a great many years as a worthless appendage after it had served its primal purpose. It is true that pipes of peace have been made out of it; but now comes the Department of Agriculture and is ready to utilize it, for it has been found that 35 per cent of it is transformable into crystalline glucose, which has many uses, one of them being the production of alcohol. Another use is adhesive, which is used in making fiber boards and paper boxes. This adhesive could be made colorless and would replace the starch, dextrine and flour paste, and only 3 per cent of the cobs would have to be used to replace all this.—Compressed Air Magazine.

U. S. Civil Service Commission announces an examination for mechanical draftsman, to fill vacancies occurring in the Office of the Chief of Ordnance, War Department, Washington, D. C., and in positions requiring similar qualifications, at salaries ranging from $800 to $2500. Until further notice, applications will be received at any time. Competitors will be rated on education, training, experience, and practical tests, rated on work submitted. Apply for Form 1312.



Protective Relays---I

TYPES AND THEIR APPLICATION TO POWER GENERATING SYSTEMS. BY VICTOR H. TODD

SHORTLY after the advent of the circuit-breaker, it was found that in order to protect a circuit effectively and accurately from any abnormal conditions which the circuit-breaker could not detect, it was necessary to have an auxiliary instrument accurately constructed and tested, which was operated by the main currents and which controlled the opening of the larger and necessarily rougher constructed circuit-breaker. This instrument is called a protective relay, and has been so specialized and highly developed that there is practically no electrical defect or abnormal condition which can occur in a system, that a relay cannot be had to detect and protect the circuit against it. Overload, excess current, overvoltage, undervoltage, reverse current or power, high or low frequency, high or low temperature, reverse phases, and numerous other conditions which may occur, all can be detected by a suitable relay.

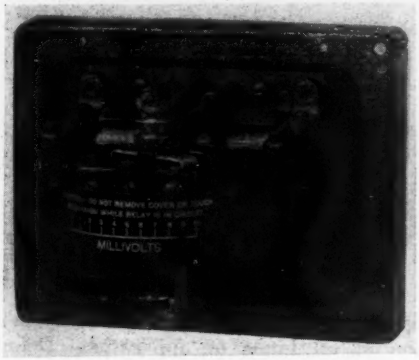


FIG. 1. TYPICAL RELAY OPERATING ON THE D'ARSONVAL PRINCIPLE

As the advantages of protective relays are becoming better known and as they are realized to be an important and necessary auxiliary of every up-to-date power plant, the following questions are often asked: "What kind of a relay shall we purchase?" "What is best adapted to our needs?" "What trip circuit and method of tripping breakers shall we employ?"

As to the principles of operation of protective relays, practically every method used in making voltmeters, ammeters and wattmeters has been used, but it has gradually settled down to three main divisions, however: The D'Arsonval principle, employing a moving coil and permanent or electromagnets is used extensively for direct-current work. A typical relay of this type is shown in Fig. 1. The induction principle is used extensively on alternating current circuits. A typical alternating current induction type relay is shown in Fig. 2.

The solenoid and plunger principle of which the relay shown in Fig. 3 is an exponent, is employed successfully on both direct current and alternating current. Two of

FIG. 2. TYPICAL INDUCTION TYPE RELAY

the other types which have found favor due to their good operation are the telegraph relay type for direct current shown in Fig. 4 and the motor type for alternating current shown in Fig. 5.

APPLICATION OF D'ARSONVAL TYPE

THE direct current relay (Fig. 1) is used extensively in battery charging work for detecting the following abnormal conditions: Excess current, under current, overvoltage, undervoltage, and reverse current. It is the only type which can be set with extreme accuracy but is easily burned out and if extreme accuracy is not essential, the more rugged, but less accurate plunger type should be employed.

This type is also used to detect a generator which has lost its field and is consequently being motored.

It is used in direct current radial systems of trans-

mission and for parallel and ring systems to secure uninterrupted service in factories. It is also used extensively in connection with a bridge box and exploring coil to detect high and low temperatures in motors, generators and transformers, and either open the circuit, sound an alarm, or start cooling pumps or blowers.

The Induction Type

The induction relay is used extensively to detect overloads and underloads, over and undervoltage; for differential protection of feeders and transformers; for radial systems of transmission; for reverse phases; and for detection of excess current and excess temperature at the same time. The induction type is one of the most

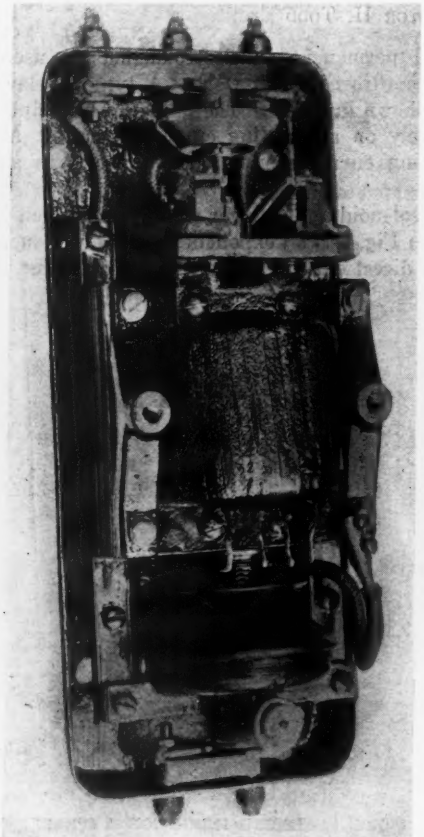


FIG. 3. TYPICAL SOLENOID-PLUNGER TYPE RELAY

accurate, rugged, easily adjusted and dependable relays ever developed. As will be shown by a later comparison, it is vastly superior to the solenoid-plunger type.

The Solenoid-Plunger Type

This type has been employed successfully on alternating current and direct current to detect overloads. In a few cases, they have been used in radial systems of transmission and for the differential protection of transformers. Their use is justified only by their rugged construction and cheap initial cost; but as the induction relay is gradually becoming less expensive and is becoming more rugged, it is safe to say that the solenoid-plunger type will be entirely obsolete in a few years.

Time Delay of Relays

One of the main objects of certain relays is to secure a certain time delay between the occurrence of an abnormal condition and the tripping of the breaker. This is secured in the D'Arsonval type by the inherent damping of the bobbin; in the induction type by permanent magnets acting on the disc and in the solenoid-plunger type, by an air bellows or oil dashpot retarding the motion.

Classed as to time, relays may be inverse time, in which the time delay is inversely proportional to the extent or magnitude of the abnormal condition; definite time, in which there is a definite time regardless of the magnitude of the abnormality; inverse-definite, in which the delay is inverse up to a certain magnitude, after which it becomes definite; and instantaneous, in which there is practically no time delay.

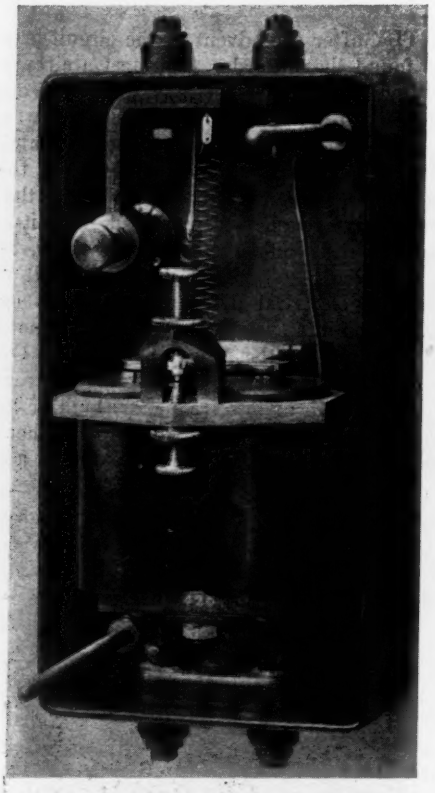


FIG. 4. TELEGRAPH TYPE RELAY

Inverse time relays are used extensively in overload protection of all kinds of apparatus. Definite time relays were used in sectionalizing a radial system, and inverse-definite time limit relays as exemplified by the induction type are being used for both classes. Instantaneous trip relays are used where there is no possible chance of an overload clearing itself in a few seconds as for instance, there is small chance for an internal "short" in a transformer clearing itself or "burning out"; but there is a good chance of a short on a transmission line clearing itself in one or two seconds, as it may be only a small wire dropped across the lines and the big rush of current may burn it out and relieve the short before the relay trips the breaker and thus continuous service is preserved.

Trip Circuits

There are several methods of controlling or "trip-

ping'' the breaker. The two main classes are circuit closing or shunt trip, and circuit opening or series trip. In shunt tripping, the relay closes two contacts which in turn close an auxiliary direct current circuit to a coil on the breaker which attracts an armature and thus trips the breaker. This is perhaps the most reliable system, but requires an absolutely dependable direct current source of supply such as an independent storage battery. The exciter bus should never be used for a trip circuit, as a disturbance on the high-tension side may so disturb the exciter bus that there is no voltage for tripping just at the critical moment.

With series tripping, the tripping coil is connected in series with the relay and current transformer, but is short-circuited by two contacts in the relay. Upon the operation of the relay, these contacts are opened thus shunting the current through the trip coil. This is unsatisfactory, as rattling or dirty contacts or very excessive overload will sometimes trip a breaker without proper cause or time. In the type in which the contact is closed positively by a toggle joint, the relay must be reset by hand after each tripping.

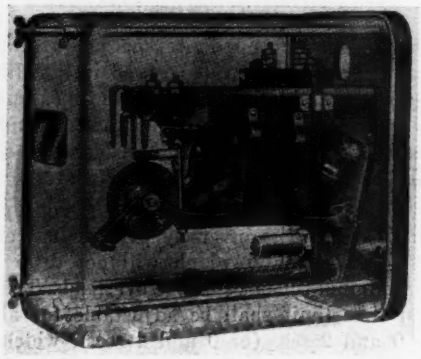


FIG. 5. OVERLOAD RELAY—MOTOR TYPE

All the difficulties of series tripping have been overcome and the advantages retained by a new development called a "transfer relay." This system employs circuit-closing relays for the detection of an abnormal condition and a transfer relay to cut the trip coil into the series circuit at the proper instant. This is shown in Fig. 6.

Induction vs. Solenoid-Plunger Relays

There are a number of disadvantages in the solenoid-plunger relays which are not present in the induction type. In the air bellows lagged type, the time is very inaccurate and unreliable due to the drying out of the leather.

Another difficulty is, that the continuous vibration to which they are subjected gradually loosens the nuts, screws, etc., unless the relay is unusually well built. The noise is also objectionable. The force on the plunger increases as the square of the current, with the result that the forces reach such enormous values during a heavy overload that the leather may be stretched or even burst. It is no uncommon thing for relays of this type to be so badly damaged that they will fail to operate the next time another short circuit occurs.

The definite time limit relay is not subject to such defects in the bellows due to overload, but their inherent variation in time makes them unreliable for selective action closer than about one second. Another disadvantage of bellows type relays is that, once the cone is lifted, then in order to reset, the current must drop to 40 or 50 per cent of the minimum tripping value.

The oil-damped relays are not at all permanently accurate and change in time greatly due to changes in the viscosity of the oil upon changes in temperature.

An objection to the use of all solenoid-plunger relays is that the expense of adjusting them for accurate work is often greater than the cost of the relays themselves. It is possible that an automatic sectionalizing scheme could be so laid out that time limits varying by steps of one to two seconds could be used, in which case the bellows type of relay might be sufficiently accurate, but

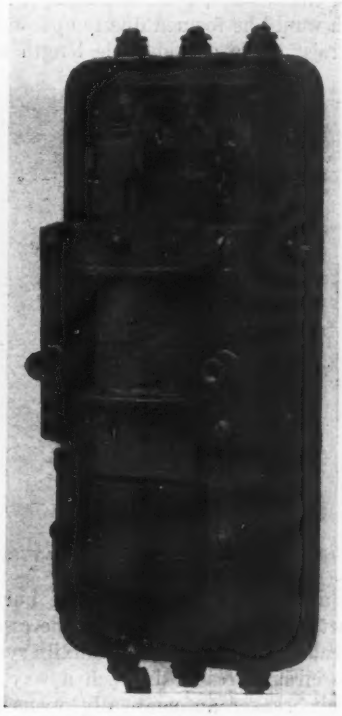


FIG. 6. TRANSFER RELAY

such accuracy could not be obtained except at considerable expense. In order to adjust relays of this type it is generally necessary to disconnect them from the circuit and connect them to a test circuit, which in many cases is not easy to obtain. In addition, a chronograph, ammeter and control device are necessary. Needless to say, such a calibration must be made by a skilled tester. If a change in the time limit is later required it is necessary to repeat the entire process.

The best feature of the induction type of overload relay is its remarkable accuracy and permanence of calibration. The use of permanent magnets as a time-limit device prevents over-swinging and chattering of the contacts, and the construction is such that the relay will instantly cease its movement when the overload disappears. There is no possibility of mechanical injury due to excessive currents when the torque compensator

is used, because the saturation of the iron prevents the mechanical forces from increasing beyond a certain amount.

The current and time adjustment of the induction relays are plainly and accurately marked and any desired change can be made at a moment's notice. This is a feature much appreciated by the operating man who is responsible for the successful operation of the automatic sectionalizing devices on his system. He can personally check the setting of every relay and thus be sure that no incorrect operation will result due to the carelessness or incompetence of an assistant.

Relay Contacts

One difficulty in relay operation that requires consideration is that which occurs due to the burning of the contacts when heavy tripping currents are handled. The tripping circuits are, as a rule, highly inductive, and an arc which would be formed due to opening such a circuit will persist for a considerable length of time and

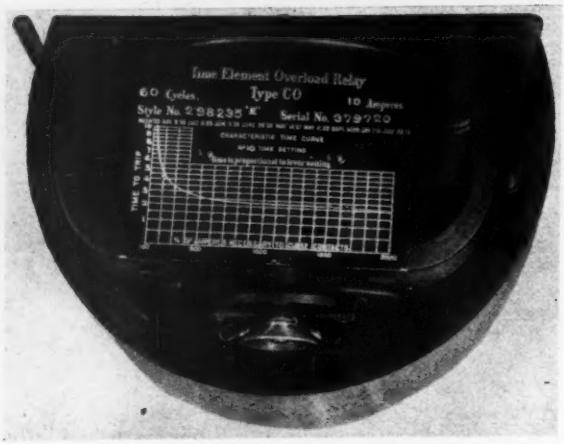


FIG. 7. SHOWING AUXILIARY RELAY SWITCH

thus cause an unnecessary amount of burning on the relay contacts. For this reason it is necessary that the tripping circuit be opened by an auxiliary switch fastened to the circuit-breaker in such a way the opening of the circuit-breaker automatically opens the tripping circuit. It sometimes happens that large circuit-breakers require a much heavier current to trip them than can safely be carried by the relays. This difficulty is overcome by the use of an auxiliary relay switch (control relay) which is operated by the protective relay and which closes the tripping circuit of the main circuit-breaker. Sometimes this is mounted in the relay case as shown in Fig. 7. A control relay is also used when it is desired to trip several circuit-breakers from one relay.

Load on Instrument Transformer

When selecting a relay for use on current transformers which also operate instruments, it is important to consider the load which the relay places on the transformer. The induction type of relay requires a smaller amount of energy than does any other type, a feature to be appreciated when bushing-type current transformers are used. When transformers of this type are heavily loaded their ratio is not constant and there is also a noticeable difference in phase between the primary and secondary current. The reverse-power relays require such a small amount of energy that the phase angle error will not be great enough to affect their operation even if they are used on bushing-type current transformers having a small ratio of transformation.

In selecting a reverse-power relay it is not only important to obtain one having satisfactory operating characteristics, but the question of convenience in checking its connections must be considered. If the relay is a sensitive one it can be tested by feeding a small amount of power through it in the reverse direction. On some systems, the power loss in a bank of transformers located on the line side of the relays may be sufficient to cause their selective elements to operate backwards and thus test their reliability. On the other hand, a relay which required 5 or 10 per cent reversal of power in order to operate it cannot be tested except at great expense and it is usually necessary to determine by more or less costly experience whether or not the relays are connected backwards.

Relay Specifications

In order that cheap imitations of overload and reverse power relays may not be used in installations it is always well to add the following specifications. If a relay meets these fundamental requirements and is well constructed, it should be satisfactory, but these specifications will bar the undesirable relays.

"Overload protective relays shall be equipped with a time limit that varies inversely with the current at all moderate overloads and which will not drop below a definite minimum time at extreme overloads. The definite minimum time limit shall be adjustable for all values between 0 and 2 sec. (or 0 and 4 sec.), which adjustment shall be accurate and permanent. The relays shall be calibrated at the factory, and the calibrating date shall be fixed to the front of the relay. It shall be possible to make without the use of any testing equipment or timing devices, independent adjustment of both the time limit and the overload value at which the relay will operate. Relays shall be so constructed that they will not be damaged or their calibration affected by the maximum current that the generating equipment can deliver to them. Their construction shall be such that in case an overload ceases before the relay contacts have been closed, the relay will instantly commence to reset to its starting position. The energy that the current transformer must furnish to operate a relay, shall not be in excess of 20 v.-amp.

"Reverse power relays shall be equipped with an adjustable time limit feature that will satisfy all the requirements previously specified for overload time limit relays. They shall be selective with regard to direction of power flow under all conditions of low power factor, and unbalanced short circuits, and they shall be selective at 2 per cent of normal voltage upon the occurrence of an overload of 300 per cent or more. They shall be so constructed that the normal power, including moderate overloads, can flow in either direction through the circuit to which the relays are connected, without causing the relays to trip the circuit-breaker."

Typical Layout

In Fig. 8 is shown a typical layout which may be used to illustrate the uses of the different kinds of relays.

There are six generators shown which feed through individual switches, to the low-tension bus. Each generator is protected by relays shown at 1, which may be overload, definite limit relays of the plunger or induction type, or reverse power relays with current setting slightly less than the sustained short-circuit current of the generators; or they may be differentially connected overload relays, connected to trip instantly the breaker in case of a fault in the winding.

The bus is arranged to sectionalize in three sections. so if any bus section becomes defective, the overload relays, 2, which should be of the instantaneous plunger or induction type, will instantly sectionalize the bus.

The low-tension bus is arranged to feed four step-up transformers (on the left) and a low-tension radial system (on the right). Each step-up transformer bank is protected by instantaneous, differentially connected overload relays (4). These trip out an individual bank in case of internal trouble. The transformers are protected from overload by the inverse-definite minimum time limit relays of the induction type shown at 3. The high-tension bus is also capable of being sectionalized by the instantaneous overload relay (2). From this bus, transmission lines run to two substations, A and B Each station is fed with two parallel feeders, protected at the generating end by overload, inverse-definite-minimum time limit relays (5) and at the receiving end by reverse overload relays, 6 and 7. Between the two stations is run another line, making a ring system. This tie feeder is protected by reverse overload relays.

Relays (3) should be set for about 2 sec.; relays (5) for 1½ sec.; relays (6) and (7) for 0.5 sec.; and relays (8) for 1 sec.

The high-tension is stepped down by two transformers at A. These are protected by instantaneous, differentially connected relays (4) and overload relays (9) set low about 1 sec. The low tension bus feeds three rotary convertors which feed a 3-wire direct current system, a storage battery and a direct current motor load. Relay (10) may be an overload relay with under and over voltage auxiliary relays. Relay (11) should be a high-grade reverse current relay. Overvoltage, overload, underload and undervoltage relays may also be used. Relay (12) should be an overload relay set about ½ sec. or instantaneous.

At substation B, the high tension is stepped down and protected as before. This secondary bus may feed a load of synchronous motors, a 3-wire alternating current system and a constant-current lighting circuit. Relays (13) may be overload or reverse phase. Relays (14) should be overload with additional under and over-voltage relays. Relay (15) should be an underload relay.

From the main station is run a radial system of parallel feeders. Relays (17), (19) and (21) are reverse power relays, set about 0.1 sec.; relays (16), (18) and (20) are accurate overload inverse, definite-minimum relays of the induction type. Relays (16) are set for 1½ sec.; (18) for 1 sec.; and (20) for ½ sec. At each substation bus is taken off a various number of loads, and each is protected by relays which may be of the plunger type as long as they operate in quicker time than the protecting sectionalizing relays.

It is evident that no one layout will suffice for all systems; neither can invariable rules be laid out for the use of any relay. It becomes a study of each individual system, but with a knowledge of the various loads, and how they divide in the event of short circuits, together with the knowledge of the maximum currents, it becomes comparatively easy to apply relays and set them to give adequate protection and reduce unintentional interruptions to an almost negligible quantity.

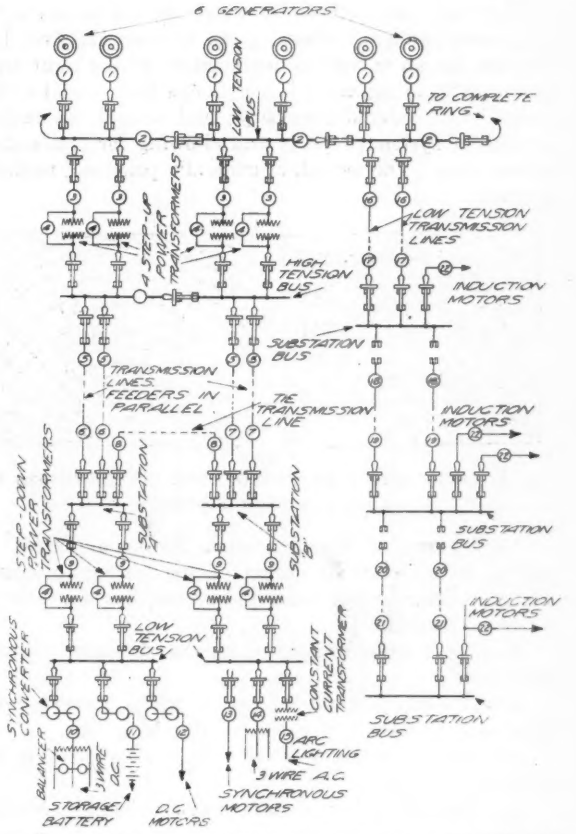


FIG. 8. INDICATING RELAYS ON TYPICAL POWER GENERATING SYSTEM

A recent issue of Electrotechnische Zeitung described an interesting lamp made for 220-v. circuits, and having a current consumption of 1 to 5 w. It is suitable for use as a signal lamp or in places where inflammable gases are met, as it is immediately extinguished if the bulb is damaged. The lamp depends on the discharge of electricity in an atmosphere of neon. The cathode is of large area and hemispherical shape; while the anode, in the form of a wire, reaches such a small distance from the edge of the cathode that a brush discharge starts without external aid at 220 v. The orange color of the neon light is corrected by mercury vapor and a pinkish-white light thus obtained.—Scientific American.

Maintenance of Lighting Systems*

CLEANING, CLEANING SCHEDULES AND LAMP REPLACEMENTS; NOTES ON REFINISHING OF INTERIORS

DIRTY REFLECTORS, walls and ceilings darkened by smoke and dust, blackened lamps left in service as long as they continued to burn, empty sockets, unobserved burnouts, and replacements with lamps of wrong size or improper voltage rating are prime causes of inadequate illumination.

There are two methods by which the maintenance of any selected value of intensity can be assured: first, by allowing for an enormous depreciation in the light and consequently using much larger lamps than would ordinarily be considered necessary; and second, by maintaining the system properly and allowing for reasonable depreciation. The second, or generally practical, method involves:

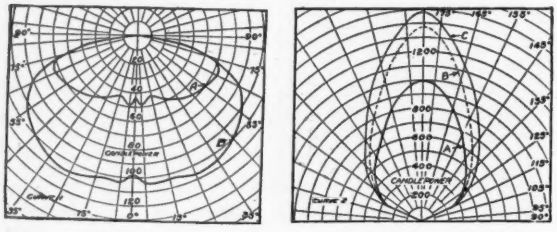


FIG. 1. DUST AND DIRT DESTROY THE EFFECTIVENESS OF LIGHTING EQUIPMENT

1—The use of a depreciation factor, or factor of safety, in the original design of the system to insure adequate illumination when the system has depreciated a normal amount;

2—The cleaning of lighting units at frequent, regular intervals;

3—The replacement of lamps which have become blackened in service by abnormally long life;

4—The use of lamps of the correct voltage rating for all replacements;

5—The refinishing of ceilings and walls at reasonable intervals.

DEPRECIATION FACTOR IN ILLUMINATING DESIGN

THE PURPOSE of the depreciation factor is to insure adequate illumination when the installation shows maximum depreciation under the system of cleaning adopted. For example, where units are cleaned and inspected every three weeks, the illumination just before cleaning may be 15 per cent lower than immediately after. Furthermore, the ceiling and walls will gradually become darkened, so that the illumination at the end of a year, even with the lighting units thoroughly cleaned and the lamps in excellent condition, will be materially lower than when the installation was new. In order to insure that illumination will at no time be inadequate, it is necessary to add a suitable amount to the intensity considered desirable and design for this larger amount initially.

How dust and dirt destroy the effectiveness of lighting units is strikingly shown in Fig. 1. A point which is not apparent from the curves but which should be mentioned in this connection is that a dirty installation is likely to be more objectionable from the standpoints of glare and density of shadows than one which is clean. Glare is somewhat a matter of brightness contrast, and a bright bulb against a dirty reflector, or a bright unit against a blackened ceiling, may appreciably accentuate glare. The density of shadows depends, among other things, upon the areas of the light sources, and where reflectors are dirty, their contribution of diffused light is lost and dark, sharp shadows result.

How large an amount should be added to the intensity considered adequate, or, what amounts to the same thing, by how large a factor the intensity considered adequate should be multiplied, to insure proper illumination at all times, depends upon the specific conditions surrounding any particular installation. In general, when installed in relatively favorable locations, open-reflector units show a depreciation which ranges from 10 to 25 per cent in four weeks' time. When excessive smoke and dust are the rule, the depreciation over the same period may be as high as 40 per cent. The depreciation of ceilings and walls depends not only upon the characteristics of the location, i. e., whether clean or dirty, but upon their original color as well. The only factor which is not affected by location is the depreciation of lamps with burning. Mazda C lamps average about 95 per cent of their initial light output throughout life; the output at the end of rated life is usually about 92 per cent of initial and where there are only one or two lamps in a room, lamp depreciation must be based upon this figure rather than upon the average output. While the total depreciation of lighting systems over a given period will, of course, vary widely, experience has shown that a factor of 1.2 for very clean locations and very clean operations (16⅔ per cent loss), and a factor of 1.5 for dirty locations and relatively dirty operations (33⅓ per cent loss), may be used with assurance of satisfactory results, *provided that a schedule of regular and frequent cleaning be adopted and adhered to.*

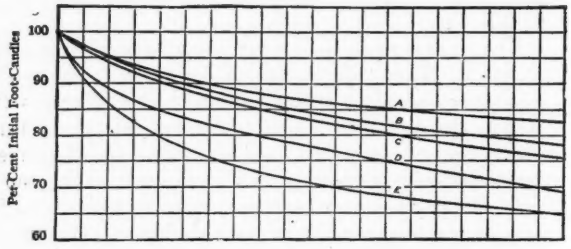


FIG. 2. EFFECT ON ILLUMINATION INTENSITY OF COLLECTION OF DUST ON LAMPS AND REFLECTORS

DIFFERENT PHASES OF MAINTENANCE

THE CURVES of Fig. 2 show the relative rapidity with which various systems of open-reflector units depreciate due to dust and dirt. The values from which these

* Abstract of Bulletin 40 prepared and distributed by the National Lamp Works of General Electric Co.

curves are plotted were obtained by measuring the illumination intensity at the work. In this way the effect on the resulting illumination of deposits on the inside and the outside of the reflecting and diffusing surfaces is correctly weighted; a result not obtained when units are measured in a photometer for total light output.

Reference to Curve 2 will show that there is a great difference between merely wiping out a unit and washing it thoroughly. On the average, wiping out has about two-thirds the effect of a thorough washing. Obviously, in arriving at any cleaning schedule, the care with which the work is to be done is an important consideration.

As has been pointed out, the importance of the factors affecting the rate of depreciation of a lighting system is largely dependent upon local conditions, and it is difficult to formulate cleaning schedules which will be generally applicable. The schedules suggested in the table may be used as a basis for formulating a schedule adapted to specific conditions; however, a man with a foot-candle meter is the best judge of individual requirements.

It is of the utmost importance that the responsibility for proper maintenance of the lighting system be definitely assigned. Experience proves that unless there is a clear understanding on this point, the work is never properly handled. A definite schedule should be outlined and carefully enforced.

It is unfortunate that, in the design of lighting systems, more attention is not given to accessibility for cleaning. Yet even when careful thought is given to this factor, it is frequently necessary because of other considerations to place units where they are very difficult of access. In many industrial plants, such, for example, as steel mills, units can be reached for cleaning only from the traveling crane and the fact that this crane is likely to be in service 24 hr. a day, six days in the week, complicates the maintenance problem. Where such conditions exist, it is advisable to go over the system every week end rather than to attempt to operate a 5-day or a 10-day cleaning schedule. In some cases, it will be found practical to substitute clean units for dirty ones throughout a section of a plant, clean the dirty ones, and substitute them for others in another section, etc. This can be done readily by using standard devices for connecting to and disconnecting from the circuit.

Where units are so placed that their proper maintenance involves considerable difficulty or perhaps danger to the one who looks after them, the investment in some form of disconnecting hanger which permits the units to be lowered to the floor, is advisable.

Some units are, of course, easier to clean than others, but, with the exception of certain types built up of plaster or composition and those employing polished metal, all require a thorough washing at least as often as every third or fourth cleaning period A small stiff brush will often be found to expedite the work. Warm water and soap appear to be about as effective as the chemical cleaners for general use, although where the reflectors become stained, as by exposure to fumes, the latter facilitate the work. Any prepared cleaners which give satisfactory results in the bathroom of a home may be used without fear of their damaging the reflecting surfaces of lighting units. Where mirrored reflectors are washed, special attention should be given to avoiding injury to the backing.

Replacement of Lamps

Manufacturers, through improvements in lamp making, have succeeded in producing lamps in which the candlepower is well maintained throughout life, and blackened bulbs are continually decreasing in number. However, individual lamps show considerable variation from the average performance, and where inspection shows a bulb to be considerably darkened the lamp should be replaced with a new one.

While it can be shown that it is cheaper to replace a blackened lamp with a new one under most operating conditions, the consideration of greater importance is the fact that blackened bulbs absorb light which is needed upon the desk tops, machines, or counters, as the case may be. The inspection of lamps for this cause of lighting depreciation is simple and it should be done at each cleaning period.

The cleaning of any unit should not be considered complete until it has been lighted to insure that the lamp or lamps operate. Where several lamps are used in an indirect or dense semi-indirect bowl, one or more may fail without the effect in the illumination being at once apparent unless the maintenance man examines the

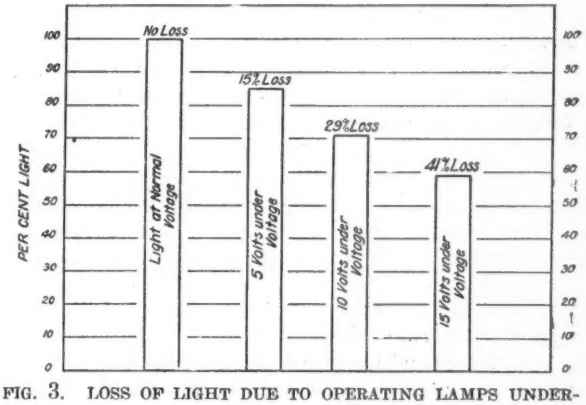


FIG. 3. LOSS OF LIGHT DUE TO OPERATING LAMPS UNDER-VOLTAGE, BASED ON 115-V. LAMPS

fixture for this possibility. On the other hand, where a single large lamp is used in such bowls, a lamp failure is at once observed. The cleaners should carry a supply of lamps of the proper size with them so that a burned-out bulb may be replaced immediately.

Lamp Voltage Ratings

Mazda lamps are rated for a given light output at a certain voltage. On a lower voltage a lamp will give less light, and on a higher voltage, more light. This fact is generally understood, but few appreciate that the variation in light output is several times as great as the variation in voltage. The chart of Fig. 3 shows the relation between light output and voltage as obtained by exhaustive tests on many groups of lamps. A difference between rated voltage and operating voltage of a few per cent is accompanied by a percentage difference in light output about 3.5 times as great.

Refinishing of Ceiling and Walls

How frequently an interior requires refinishing depends upon: the type of lighting, whether direct, semi-indirect, or totally indirect; the nature of the finish

employed; the characteristics of the location, whether relatively clean or dirty; and, in less degree, upon the color of the finished surfaces.

Reflectors in a direct lighting system themselves turn light into downward directions and make the effectiveness of the system less dependent upon reflection from the ceiling and walls than where other units are used. Enclosing units amid light-colored surroundings produce a distinctly pleasant brightness; amid dark surroundings, they furnish much less light and, frequently, are excessively glaring. Again, semi-indirect and totally indirect systems depend essentially upon good reflection from the ceiling and, to a less extent, from the walls, for their effectiveness.

Fortunately, considerations of appearance often dictate the refinishing of a soiled and gloomy interior where the expenditure from a lighting standpoint alone would not have suggested itself. However, ceilings and walls, like other reflecting surfaces, lose much of their effectiveness before the accumulation of dust has reached the point where the surfaces appear badly in need of refinishing. For this reason, it should be the duty of the maintenance department to ascertain the condition of the walls and ceiling and to see that they are kept in a good reflecting condition.

A white paint or plaster surface absorbs less light than any other interior finish. Yellowish or warm-toned paints are considered desirable in many cases on account of the cheerful, pleasant atmosphere created. Such tones reflect a larger proportion of artificial light striking them than blue tones, although the latter may appear at first glance equally light. The reason for this is that the light from the ordinary Mazda lamp contains a higher percentage of yellow and red rays than blue rays, and a surface of a tone other than white reflects a greater proportion of the rays of its own color than of another color. This is the basis of the common recommendation that where a white paint is not wanted a paint of a light-cream tone may be used without marked sacrifice in lighting effectiveness.

SUGGESTED LAMP-CLEANING SCHEDULES

Where direct lighting systems are used, i. e., where there are no reflecting or diffusing surfaces concave upward to invite dirt accumulation, the interval of cleaning should be about as follows:

Characteristic of Location	Interval in Days if Units are Wiped out*	Interval in Days if Units are Thoroughly Washed
Very Dirty	3	5
Dirty	7	10
Average	15	20
Clean	30	40

Where open semi-indirect or totally indirect units are used:

Characteristic of Location	Interval in Days if Units are Wiped out*	Interval in Days if Units are Thoroughly Washed
Dirty	5	7
Average	10	15
Clean	20	30

*Washing every third or fourth interval assumed.

The Enemy Foiled

YOUNG AMERICAN OFFICER REVEALS TREACHEROUS TACTICS OF GERMAN AGENT ON OCEAN LINER. BY A. W. KRAMER

THE engine room telegraph aboard the U. S. S. Western Star clanged noisily. The pointer swung slowly to and fro across the enameled dial, hesitated for an instant, and finally came to rest at "Full Speed Ahead." Ensign Robert Murdock, engineer on watch, swiftly grasped the answering lever and with a vigorous swing sent the acknowledgment back to the bridge.

"All right, Perkins," he shouted to the engine man at the throttle, "open her up. Give her 200 lb."

As the engine man spun the shining wheel around, the pointer on the steam gage slowly climbed to the 200-lb. mark and the monotonous whine of the 2500-hp. driving turbine rose in pitch until it screamed deafeningly. The tachometer became steady at 3600 r.p.m.

Murdock, eyeing the steam gage with satisfaction, recorded the change in speed in the steam log, and remarked cheerfully, "Let's hope we can keep her wide open now, Perkins. I don't care much for the slow speed at which we have been steaming. Here we are, nine days on our way from New York and still 1600 mi. to go before reaching the coast of France. It's bad enough being on a 10-knot, 90-day cargo tramp without holding the speed down to eight knots for the sake of a few ships in convoy. By the way, what time is it? I almost forgot to enter it in the log."

"Two a. m., sir," answered Perkins as he grinned at his superior. He knew that it was Murdock's first trip on the vessel and could readily understand his impatience. For the past two days, on account of two temporarily disabled ships, the speed of the convoy had been reduced to eight knots.

Twenty minutes later, or exactly at 20 min. past two, the steady roar of the big engine suddenly changed its note—almost imperceptibly, to be sure, but on the ears of Murdock it fell with the suddenness of a lightning crash. Wheeling around, he glanced at the oil-pressure gage on the forward turbine bearing, and then, with a flying leap, dislodged the good-natured Perkins from his recumbent position against the throttle, spun the wheel to the stop position and was admitting steam into the reverse element before the surprised engine man had recovered his footing.

The heavy rotor groaned under the terrific strain—high pressure steam issued from the bearings. It was a struggle between steam and steel. Steam, however, was victorious and, in less than one minute, Murdock had brought the 10-ton rotor to a dead stop. He had saved the big machine from destruction. In another minute, had it continued to run, the bearings would have given way, due to failure of the oil supply. Oil is the life blood of the turbine and, when Murdock had found the oil pressure down to zero he had realized that the only way to save the machine was to stop it.

Stopping a ship at sea is a serious thing and is never done except as a last resort. The offense is doubly grave when steaming in convoy through a "sub"-

infested danger zone. This Murdock knew. But it had been his only choice—there had been no alternative. These thoughts flashed through his mind while he manipulated the throttle. An instant later, the shrill whistle of the speaking tube broke the ominous silence which now filled the engine room, and, as he put his ear to the tube, the excited voice of the chief engineer came down from above.

"What happened down there, Murdock?" he inquired anxiously.

"The oil pressure dropped, sir. It suddenly fell off without warning and I was forced to shut down. Can you come down here, chief? I don't know how serious the trouble is."

"I'll be down immediately. In the meantime, open up the floor plates so we can examine the oil lines. I will notify the bridge. There will be hell to pay."

With these instructions from the chief, Murdock turned to the engine man, who, by, this time, was aware of what had occurred.

"More trouble, Perkins; get two firemen from the fire room and remove the floor plates from over the oil lines. There must be a break somewhere."

The lubricating system had been entirely laid bare by the time the chief arrived, but, instead of disclosing a broken pipe line, all was found to be intact. Every joint was perfectly oil tight.

The chief was worried and in an angry mood. "Now what's wrong, Murdock?" he inquired accusingly. "Do you realize how serious this is? You have been falling down lately—this is the third accident that has occurred while you have been on watch. I'll have to report you for incompetency."

Murdock's face flushed under the reprimand. Indeed, it was serious for him. The chief's accusations were true—at least, as far as actual facts were concerned. Twice before, peculiar accidents had occurred on his watch. One night, a week previous, the main suction line to the boiler feed pump had suddenly opened up underneath the floor plates, although he had personally examined the line an hour before and had found it in perfect condition. As a consequence, they had been compelled to shut down for an hour. Two nights ago, three spring bearings in the shaft alley had become hot and had been ruined before anything could be done. Examination had shown the bearing surfaces to have been deeply cut, as though sand had gotten into them. The oiler who had oiled them a short time before had claimed that at that time they had been cool and running smoothly. Temporary repairs had avoided the necessity of stopping. Tonight, the oil pressure on the turbine bearings had suddenly dropped, and, but for his quick action, the 2500-hp. turbine would have ruined its bearings. Fate seemed to be against him. But was it fate? Were these really accidents? Could not somebody have perpetrated them? Could there be anybody aboard ship desirous of injuring his reputation? These thoughts flashed through his mind as he faced his chief.

"I'm sorry, sir, I have tried my best. Facts are against me, I know; yet I assure you these accidents have not resulted from lack of watchfulness on my part. I am fully aware of their serious nature and would have done anything to prevent them had it been in my power to do so."

"That is no excuse, Murdock. After the eight months of training in steam engineering which you received at the Government school, you should be able to anticipate such accidents as these and also to prevent them. The fact that you did not prevent them does not speak very well for your capability. To be of any use down here, one must be wide awake at all times. Had you watched closely, you would have noticed a gradual decrease in pressure on the oil system and you would have had time to notify me."

Murdock was silent. He could not argue the case with his superior, though the words had cut him deeply. He had done his best. His training in marine engineering had been thorough and had well equipped him for his work aboard ship. In his own mind, he knew it was not a question of incompetency.

"How about the oil filters, Murdock?" asked the chief. "Have you cleaned them tonight?"

"Yes, sir, as soon as I came on watch—they were fairly clean."

"Well, let's get at them first. Get a wrench, Parks," the chief directed, "and open up these strainers; and, Murdock, you close the discharge valve to the main bearings so as to prevent the oil from flooding the filters when we open them up."

Murdock let himself down into the bilges, which were about 4 ft. below the engine room floor plates, and reached down to close the discharge valve. Under operating conditions, this valve is, of course, always wide open, since to close it would cut off the oil supply to the turbine bearings. Jerking the wheel, Murdock found it stuck tight. After several futile attempts to loosen it, he carefully examined the valve, and to his great amazement found it tightly closed! He was dumbfounded. How could it have become closed? Certainly no one had touched it since the turbine had been stopped.

Hurriedly emerging from the maze of pipe lines, he called out excitedly, "Why, it's closed, chief! Tightly closed! I cannot account for it. Surely nobody in the engine room was down there tonight."

"Closed," echoed the amazed chief, "how the hell could it have become closed if nobody closed it? Open it up, man, quick!"

Once more grasping the valve wheel, Murdock jerked it in the "open" direction and found that it responded easily. The oil pressure immediately came on, and the chief, who had been watching the gage, called to Murdock to come up.

"Humph!" he grunted, highly enraged. "You're a hell of an engineer. What do you think you're on—a pleasure launch? Don't tell me you didn't close that valve. This is a court martial offense, and unless you can clear yourself satisfactorily, I'll see that you get one. Understand, I'll give you one week. Now, get her started. Parks," he ordered, turning to the oiler, "tell the firemen to start up the furnaces! Perkins, get at your post! Open her up slowly. Murdock," continued the chief, as he turned to go above, "see that nothing else occurs. I'll try to explain to the bridge; in the meantime keep your eyes open."

* * * *

The commotion which had prevailed during the early part of the watch had entirely subsided. It was nearly four o'clock; in another half hour the watch would change. Murdock stood alone in deep thought at the

far end of the shaft alley. He had gone back there to inspect the stern bearings and had accidentally stumbled upon a clue which promised to explain, not only the mysterious event of tonight, but also the two previous accidents which had occurred on this trip. While walking through the long passage way, his searching eyes had discovered faint, white foot-prints upon the dark, oil-soaked boards which formed the walk. Curious, he had looked into the bilges, where he found an overturned can of white paint. Somebody had evidently walked through this paint unknowingly, and, after getting up on the boardwalk, had left the white foot-prints on the dark boards. Following them until they had grown so faint as to be almost indiscernible, he discovered that the trail led directly towards the stern end of the shaft alley where the escape vent was located. This escape vent served the double purpose of a ventilator and also as a means of egress from the engine room in case of emergency. It led to the poop deck and was rarely used by anybody.

Coupling the existence of the foot-prints together with the fact that they led to the escape vent had given Murdock an idea. It would be an easy matter, he reasoned, for somebody desirous of injuring his record to come down from above by means of this vent, and, by crawling below the boards the entire length of the shaft alley, to enter the bilges below the engine room for the purpose of tampering with such pipe lines and valves as were located there. Returning the same way, such an individual could have made his escape before being observed by anybody in the engine room.

But who would do such a thing? Was there anybody aboard capable of such a contemptible act? Had he any enemies? It was true that the spirit of co-operation which should have existed between him and the other two engineers who ranked with him was lacking. This was not because of any personal ill feeling, but more in the nature of a general feeling of resentment which a minority of experienced merchant marine men harbored towards recent graduates from the Government engineering schools. Some engineers, those of the old school, who had gained their positions only by years of labor in the hard school of experience, were skeptical of the young man who had entered the service when the great emergency arose. One couldn't drop into the game through a skylight, they argued, and resented the presence of the newly appointed young officers. "Incubator wonders," they derisively termed them.

Of this type were his two associates—Brown and Ole. Although never openly hostile, they had again and again showed a decided aversion to co-operate with him. "Book learning" was of no use aboard ship, they had told him, and had laughed at his suggestions for increasing the efficiency of the power plant. Brown had several times made himself extremely disagreeable. But would they go to the extreme of endangering the ship to give vent to their jealous dispositions? It did not seem likely.

He resolved to find out. It was altogether possible that the culprit, stimulated by his previous successes in throwing discredit upon Murdock's record, would make another attempt. If he did, Murdock would catch him. Some scheme must be devised at once for trapping him "red handed."

Slowly making his way back to the engine room, he resolved to keep his discovery to himself. It was too late for any action tonight, but he would think it over and tomorrow he would proceed to carry out a plan for the detection of the malefactor.

The next night, at five minutes of twelve, Murdock ran lightly down the engine room companionway and greeted Brown, the officer on watch, with a pleasant "hello."

"Evenin'," he grunted in reply.

"How are things running tonight?" queried Murdock.

"She's hittin' 68," answered Brown. "Been runnin' right along. Hear you played hell down here last night. Some more of your theory, I s'pose. You better lay off that stuff—the chief is sore as blazes."

Murdock reddened as his anger rose.

"The trouble down here last night was no fault of mine, Brown. I guess you understand that as well as I do. I am fully capable of standing a watch down here and that will be about enough of your sarcastic remarks concerning theory. Please attend to your own affairs; I'll attend to mine."

"Oh, you will, will you?" sneered the older man. "Kind of touchy tonight, aren't you? Well, better tie a rope to the turbine, it might jump through the skylight, and don't get your fingers caught in the gears —they bite."

With this parting slam, he turned to go above, leaving the young officer in charge.

Too indignant to reply, Murdock walked away to consult the log, after which he started on the customary round of inspection. Finding everything in good working order, he left Perkins in charge of the throttle and busied himself in the following manner:

Obtaining a spool of fine insulated copper wire from the store room, he proceeded to run two wires from the engine room to the escape vent in the shaft alley in such a manner as practically to conceal them from view. This done, he affixed to the inside of the vent, at a point about a foot above the top of the shaft alley, a small contrivance which he had constructed that afternoon, composed of two brass springs and a block of wood. To one of these springs he attached a fine silk thread which, when stretched across the opening of the vent, prevented the springs from making electrical contact as long as the thread remained unbroken. Anybody coming down the vent from above, however, would break the tiny thread without being aware of it, thus causing the springs to come together. Attaching the wires to this contrivance, he hurried back to the engine room, where he completed the proceedings by connecting a battery and lamp to the other end of the wires.

"This will do the trick," he chuckled, "now, we will watch the fly get caught in the web."

Perkins, who had observed the latter part of the proceedings with no small degree of curiosity, was deeply puzzled.

"Have you taken over the electrician's job, Mr. Murdock?" he queried.

"Yes, Perkins," laughingly replied Murdock, "this job is too important to trust to the electrician. What do you think of my lighting system?"

"I can't say much for it as a source of illumination,

sir," grinned Perkins, "but I presume it serves another purpose. It's a signal, isn't it?"

"Correct," responded Murdock, "you have guessed it, but don't tell anyone; keep it to yourself and keep your eye on it. If you happen to see it light up, call me immediately, for then the fun will commence."

The hours passed slowly for Murdock that night. He waited expectantly and time after time glanced at his signal. It was now three o'clock—one more hour remained. Perhaps his suspicions were entirely unfounded, perhaps it had been a queer streak of fate—these accidents. But last night's occurrence; was that, too, an accident? No, that was unlikely—valves do not close of themselves. Somebody had closed it. Murdock leaned idly against the throttle wheel as these thoughts ran through his mind. He had sent Perkins to start up the sanitary pump.

"Mr. Murdock!"

"What is it, Perkins?"

"The signal light, sir—it's lighted," shouted Perkins.

Murdock jumped around to the side of the turbine and there, sure enough, was his signal lamp brightly lighted—somebody had come down the escape vent and had broken the thread.

"Perkins," he ordered, as the engine man returned, "connect the hose to the fire pump and have it ready to start when I tell you."

He next whistled up the speaking tube to the chief engineer's room. A half minute later a sleepy voice responded, "What is it, Murdock?"

"Please come down here at once, chief," requested Murdock. "I have discovered something. Please hurry—there isn't much time."

"Very well; I will be down in a few minutes. What is wrong?"

"Nothing, chief, but I want to show you something. There is no time to lose, sir, Please hurry."

In a few minutes the fire pump was ready to start, and Murdock uncoiled the 2-in. fire hose from its rack on the bulkhead. Parks, who in the meantime had been called from the fire room, was standing by awaiting orders.

Final preparations were now complete. Murdock only waited for the chief, who had not yet appeared. Three minutes passed. Still the chief did not come, and Murdock decided to proceed without him.

"Now, Parks," he said, "lift up this floor plate. Perkins, start the pump."

For an instant, as the water pressure came on the hose, the water swished across the floor, and, as Parks jerked up the floor plate, Murdock quickly thrust the nozzle into the opening, sending the 2-in. stream of water swishing and tearing through the bilges.

Suddenly, a muffled yelling was heard from somewhere in the bilges.

"Now we have him, men," shouted Murdock, "caught in the act. I'll drive him out through the shaft alley—get him as he comes out."

A half minute later a semi-conscious form, drenched and oil begrimed, was dragged from the bilges near the shaft alley. The powerful stream had done its work.

"Turn him over, Perkins," ordered Murdock, "let's see who it is."

Loosening the suit of "wind proofs" which the man had worn as a protection against the filth and oil of the bilges, Murdock pulled back the hood to examine the features. He stepped back in astonishment. It was the Chief Engineer.

* * * *

"It was merely another example of contemptible German duplicity, Mr. Murdock." It was the Captain speaking, a few days later. "Although a German, and in the employ of the German Government as a spy, the man had been in the American merchant marine for years, and, at the outbreak of the war, had obtained a commission in the United States Navy as a lieutenant. Serving in this capacity, he could not only supply Germany with valuable information regarding the movements of the convoys, but could also damage the machinery of the ships to which he was assigned. By having his accomplice—who, by the way, was a deck hand—answer the speaking tube, he was enabled to accomplish his dastardly work unsuspected. You were young, Mr. Murdock, and a new hand at the game; therefore, he selected you as the person on whom to throw the blame. But for your splendid work in revealing the plot, he would have succeeded. You have well earned a promotion, and I shall take pleasure in forwarding the proper recommendations to Washington."

My Experience with an Ammonia Compressor

By Daniel W. Maguire

THIS is not fiction, but a true tale of what happened to me one night, or rather one morning, about 3:30 a. m.

As you know, or if you don't, I have a Massachusetts license, one of the kind that reads something like this: "This is to certify that Daniel Webster Maguire of Westboro has been duly examined, etc."

Well, I had a job in a dairy about 4 yr. ago and my license hung on the engine room wall. Said engine room consisted of several pumps, an engine, and a couple of ammonia compressors, which were used or supposed to be used for refrigeration purposes only and not for the annihilation of life.

My job consisted of burning three wheelbarrow loads of coal in 8 hr., tending an air compressor, three or four steam pumps, going around the plant once an hour, and several other small items too numerous to mention, including the care of the ammonia compressors.

I had just come back from my rounds and was filling my pipe for a smoke when the smell of ammonia reached my nostrils. I knew that everything was not as it should be.

Now, I am what you might term a "wise guy," and, therefore, I drew forth my handkerchief, wet it, and made tracks for the engine room, at the same time nearly wrecking a perfectly good lantern that I had left standing in the passage-way between the engine and the boiler rooms.

Arrived at the engine room door, I put the wet handkerchief to my nose, closed my mouth, and with my free hand opened the door and cautiously walked over to the cause of the trouble, which happened to be one of the ammonia compressors. Making a hasty sur-

vey of the outfit, I located the trouble and with tears rolling down my cheeks and my voice choking with ammonia gas, I "beat it" for the boiler room. I had been saying things which would not look well in print, which accounts for the presence of ammonia gas in my system.

When the chief had initiated me into the beforementioned plant, he had warned me that if anything happened and he wasn't around, to call him on the phone and tell him the facts before I attempted to do anything. Therefore, lantern in hand, I proceeded to the other end of the plant, up a flight of stairs, and thence to the office.

Arrived at the office, I rang up central and took down the receiver. "Give me Mr. Blank," I ordered. "Yes, this is important."

After waiting a considerable time, central replied, "They don't answer."

"Won't you please ring him again, we've got a bad leak down here, and I must speak to him at once."

"All right," central replied, "I'll ring him again."

Another brief lapse of time, and a sleepy voice replied:

"Hello! Whatcha want?' '

"Mr. Blank?" I asked.

"Yes, what's the matter?"

"Well, this is Maguire speaking. The small ammonia compressor is leaking around the stuffing box gland where the shaft goes through; what do you want me to do about it?"

"Well, I'll tell you. Go over to the wrench board and get a wrench and tighten up on the nuts, about a quarter of a turn, and keep plenty of oil on the bearing. If this does not do, or anything else turns up, call me again. Anyway, I'll look it over in the morning. Good-bye."

With these instructions, I went back to the boiler room, got my wet handkerchief, and did as I was told.

Everything went along smoothly after that until about 6:45 a. m. and I smelled ammonia again; but, thinks I to myself, I'll let it go 'til Dave gets here, then tell him about it, and knowing more about the blame thing than I, will fix it O. K.

At seven o'clock, Dave—he was my relief—came whistling into the boiler room. He said his usual "good morning." So did I, and then he asked: "How is everything?"

"Oh, pretty good," said I, "nothing much the matter this morning except the small ammonia compressor is leaking a little around the stuffing box gland."

Now, Dave was a very conscientious workman, and before I could tell him what I had done and had gone through, he went into the engine room, looked the scene of the difficulty over, and began to work gingerly with a few of the innumerable valves therein. After doing this, he went over to the bearing where the shaft went through and felt it. He must have found it too warm or something, because I saw him slack up a little on the nuts that I had previously tightened.

Well, I didn't wait around to see or hear the outcome. I was sleepy. I had a right to be. The night before the night in question I didn't sleep, and the night in question I couldn't sleep—so there you are.

After getting a good day's sleep, when 10:45 p. m. came around I went to work again, but all through my lonely vigil nothing of importance happened.

Seven o'clock came again, and with it came Dave with his usual "good morning" and tuneful whistle.

After getting into his working duds, Dave told me how it was that the ammonia compressor was leaking through the stuffing box.

"You see, it's like this," Dave explained. "Day before yesterday, when that machine was started, the fellow that did the job forgot to open the main discharge valve, and the result was that an enormous pressure was built up and the only place for it to escape was through the stuffing box."

After Dave had concluded his explanation I let out a thankful sigh. Supposing the machine had bursted. Wow! If it had, perhaps I wouldn't be writing this tale now—if it had, well, I'll leave that to your imagination.

Fuel for Internal Combustion Engines

THE enormous and ever-increasing use of internal-combustion engines compels serious attention to the question of the source whence a fuel for such engines is to be obtained in the future. Petrol has risen in price since the introduction of motor vehicles, and it is generally believed that a considerable further advance is imminent. The development of the suction-gas producer on the lines indicated by Col. D. J. Smith at a recent meeting of the Institution of Mechanical Engineers may do much to relieve the situation as regards the heavier class of motor vehicles. It is an attempt which not only shows a great promise of success, but which deserves every encouragement from the point of view of providing users with a cheap form of fuel of British origin. Neverthleless, even if the success of the Smith producer or any kindred apparatus is as great as can be hoped for, there still remains an immense field in which some form of volatile liquid fuel forms the only practical source of power. Great things, at one time, were hoped of benzol, a home-made spirit produced as a by-product in the coking of coal. These expectations, however, have been disappointed, not so much on account of any fault of benzol as because the production of this substance is, and must remain, too small to exercise any appreciable effect upon the liquid fuel market.

For many years the eyes of engineers have been turned to alcohol as a possible substitute for petrol, and numerous attempts have been made to establish its use as a fuel for internal combustion engines. The difficulties in the way of the advocating of alcohol have been twofold; in the first place there was the fact that the Excise regulations, which were originally framed some 30 or 40 yr. ago with regard to alcoholic beverages, placed an insuperable handicap on alcohol for power purposes. If, however, this had been the only obstacle to the use of alcohol as a fuel, it is probable that the necessary modifications in the regulations might have been brought about; but the pressure to modify the legislation never grew to any formidable extent, because engineers realized that alcohol, as such, was by no means an ideal fuel. The principal objections to its use from the technical standpoint are: Firstly, that its low vapor tension at ordinary temperatures makes it difficult to

start an engine when cold. Secondly, one of the products of combustion, which is liable to be formed when alcohol is exploded with air, is acetic acid, which had a most destructive effect upon the cylinders and valves of the engine. Nevertheless the facts that the supply of the raw materials from which alcohol can be made is unlimited, and that the production of alcohol is an easy and cheap manufacturing process, combined to maintain a considerable interest in the possibilities of this form of fuel. The usual source of alcohol is the fermentation either of natural sugar or of the sugars derived from starch. It was therefore natural that efforts towards the development of an alcoholic fuel for engines should be most general in the sugar-producing countries. The beet industry of the Continent no doubt accounted largely for the interest taken by the French in the introduction of industrial alcohol, but it is to South Africa that we are indebted for the first practical development of an alcoholic fuel as a commercial enterprise of any magnitude.

South Africa, at the outbreak of war, found herself in a precarious position as regards petrol, since no mineral oils are found within the borders of any of the States of the Union. The sugar industry, however, flourishes in Natal, and no doubt the combination of these conditions was responsible for the invention of the form of alcoholic fuel now becoming generally known

VAPOR PRESSURE IN INCHES OF MERCURY

Temperature.	Pratts' Perfection Motor Spirit.	Methylated Alcohol.	Natalite.
60	1·4	1·1	1·9
65	2·6	1·8	3·6
70	3·6	2·7	4·9
75	4·8	3·6	6·8
80	5·9	4·7	8·2
85	7·1	5·7	10·2
90	8·2	6·9	12·3
95	9·3	8·0	14·5
100	10·5	9·2	16·9

as "Natalite." Of this fuel, ether forms an important constituent, the composition of Natalite by weight being as follows: Ethyl alcohol (67 O.P.), 54 per cent; ether, 45 per cent; and trimethylamine, 1 per cent. The function of the ether is to increase the vapor tension of the mixture and thus to render the fuel more readily volatizable at low temperatures than would be the case with alcohol alone. As ether is formed by the distillation of alcohol with sulphuric acid, the acid acting as a catalyst and being substantially unaffected by the process, the provision of a large quantity of ether is a matter of no great difficulty or expense. The third constituent, N ($C. H_3$)3, is of the same nature as ammonia, methyl replacing the hydrogen atoms of ammonia. Trimethylamine, like ammonia, is strongly alkaline, and neutralizes the acetic acid which is formed when alcohol is exploded with a limited supply of air. It also acts as a denaturant to render the alcohol undrinkable. Originally ammonia to the extent of 0.5 per cent by weight was used as the necessary base, together with 0.02 per cent of white arsenic as a denaturant, but the trimethylamine not only combines these functions, but, having a lower boiling point than ammonia, is preferable to the latter substance on account of being less liable to separate out from the fuel.

As regards the physical properties of Natalite, especially in respect of ease of volatilization, the following figures may be quoted from a report made by Professor Vivian B. Lewes, when the fuel was first introduced:

It therefore appears that while alcohol is uniformly below petrol in point of volatility, hence the difficulty of starting up a cold engine with it, Natalite, on the other hand, has a notably higher vapor pressure. The ether, to which this is due, also has the effect of raising the calorific value above that of alcohol alone, and, although the mixture contains only about 95,000 B.t.u. per gallon, as against 134,000 B.t.u. for petrol, a higher thermal efficiency is obtained on account of the combined oxygen. The net result seems to be that when used in an ordinary car, without adjustment of the carburetor or the engine, Natalite will give 85 to 95 per cent of the mileage per gallon which is obtainable with petrol. These figures are taken from official tests. Among the minor, but nevertheless considerable, advantages claimed for the new fuel, is the fact that it will not mix with and therefore thin the lubricating oil, and, further, if the spirit catches fire accidentally, it can be extinguished with water.—Engineering.

The Unqualified Engineer

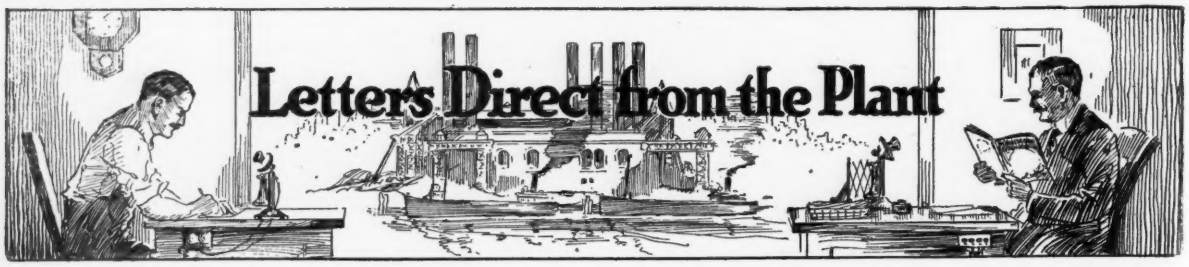
DAYS of opportunities for advancement by pull, and influence, without technical education and practical training, are past.

Before the war, there were 15 qualified men for each job, but now the reverse is true: there are 10 jobs for each man qualified for any branch of engineering. That problem alone is the hardest that the engineer has to contend with today, for, in order to keep men in the power plant, diplomacy has to be used as never before.

The chief engineer who can walk into his boiler plant, and, with a glance around him, thoroughly and correctly observe the true working conditions without having to ask the operators on duty, is the man that men like to work under, for they know that he has been there himself and can readily appreciate existing conditions. The man who has not had the experience makes a hard master to serve. H. W. ROSE.

A GLUE for belts can be prepared as follows: Soak 50 parts of gelatin in water, pour off the excess of water, and heat on the water bath. With good stirring add, first, 5 parts, by weight, of glycerine, then 10 parts, by weight, of turpentine, and 5 parts, by weight, of linseed oil varnish and thin with water as required. The ends of the belts to be glued are cut off obliquely and warmed; then the hot glue is applied and the united parts are subjected to strong pressure, allowing them to dry thus for 24 hr. before the belts are used.

IN 1920 France will need 22,000,000 tons of coal from the United States, although she does not expect to get as much. Before the war, France produced 40,000,000 tons and imported 23,000,000 tons. The war reduced both production and importation by one-half. It is possible that it will be as long as 10 or 12 yr. before the French coal situation becomes completely normal.—Chicago Commerce.



Insuring Operation of Governor Pump Motors

In a hydroelectric plant containing five generators one circuit of three-phase, 210 v. supplied the five oil pressure governor pump motors. This circuit (Fig. 1) was in conduit and some apprehension was felt concerning its reliability, as the high tail water had caused trouble during the flood season in adjacent conduits.

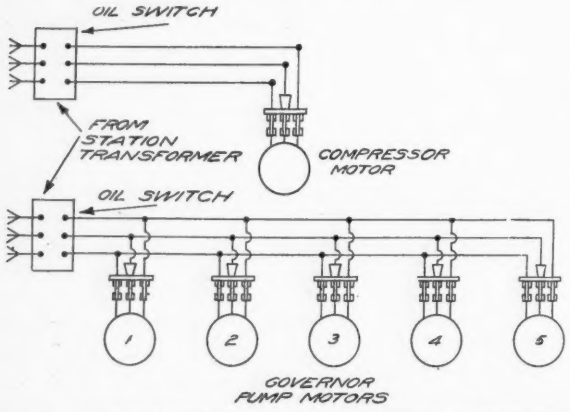


FIG. 1. DIAGRAM SHOWING ORIGINAL LAYOUT OF GOVERNOR PUMP MOTOR WIRING

It is well known that a water power plant is a bad actor when the governors do not function because it is about impossible to move the heavy gate mechanism by hand fast enough to keep the speed normal especially with a fluctuating load. In view of these facts, an auxiliary governor pump circuit was contemplated, but this would mean the use of exposed conduit which would be unsightly in a modern station. The scheme finally decided on is shown in Fig. 2. A short conduit from the compressor circuit was installed in place of an auxiliary bus.

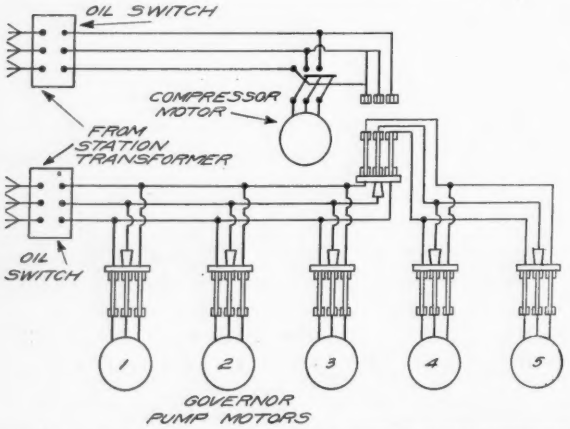


FIG. 2. CONNECTIONS BY MEANS OF WHICH SOME GOVERNOR PUMP MOTORS MAY AT ALL TIMES BE OPERATIVE

If any trouble develops in the governor pump bus, the double throw switch is thrown up. This sectionalizes the bus and if trouble has occurred in the 1-2-3 section, 4 and 5 motors will have power from the compressor circuit. On the other hand, if trouble occurs in the 4-5 section, throwing the switch up will isolate the 1-2-3 section from the trouble. The plant could be kept under control with two or three governors until temporary wiring was connected to the remaining governor pump motors.

L. W. Wyss.

Safety Valve Formulas

Referring to the March 1 issue of the magazine, I was much interested in R. G. Summer's letter, "Safety Valve Rules," page 300. As was stated, in the editor's note, there is really but one basic rule, although there may be more than one way to express that rule.

Some time ago, I had occasion to look into the matter of seeming discrepancies between Roper's and the I. C. S. rules. I might also add I made a study of the rule which appears in Reed's Engineers' Handbook, an English publication much used by marine engineers. I found that all these different expressions, or statements, will, when correctly applied and worked out on any given example, give exactly the same result. But the safety valve question continues to give considerable trouble to candidates for engineers' examinations, and I might say, always has. If candidates for examination could only be induced to learn the elementary principles instead of a worded rule, or a stated formula, they would be able to work out a problem correctly, no matter how the problem may be worded, nor by what rule it is to be worked, provided, of course, that all the factors involved, are given in the question. Therefore, it occurred to me to offer the following to readers as helpful suggestions relative to the subject at issue.

First of all, let us consider just what are all the factors that must be given, in order to work out a safety valve problem correctly. They are these: (1) Diameter of the valve, from which the area is found, against which the pressure of the steam acts to raise the valve from its seat. The area is found by multiplying the diameter in inches by itself—"squaring the diameter," as we say—and then multiplying that product by the constant 0.7854, the result is the area of the valve in square inches. (2) The pressure in pounds per square inch, which acts against the valve. (3) The weight of the valve and stem in lb. (4) The distance the center of the valve is from the fulcrum, in inches. (5) The actual weight in pounds of the lever, as may be found by weighing it on a scale.

(6) The distance, the center of gravity of the lever, is from the fulcrum, in inches. If the lever is of equal cross section throughout its entire length, then the center of gravity will be very near the center of length of the lever. If the lever is tapered, which is frequently the case, then the center of gravity will be at some point between the fulcrum and the center of the length of the lever. Ordinarily, at examinations, the lever is given as straight and parallel, and so it only becomes a matter of taking one-half of the length of the lever as the point of center of gravity. If a question should be given, in which the lever is tapered, and the center of gravity is not given as well, then the only thing the candidate can do under the circumstances, is to use his best judgment as to about where the center of gravity will be, in short, estimate its location. If good judgment is used in such a case, the answer to the problem as a whole, will not be seriously affected. (7) The length of the lever, and (8) the weight of the ball to place upon it to balance the upward force of the steam.

These eight foregoing factors complete the entire equation, or problem as a whole and complete. If any seven of them are given—and seven factors must be given—in any problem, the eighth can be found by simple arithmetic very easily.

Now, let us put the foregoing into the form of a statement or formula like this:

$$(W \times D) + (W' \times D') + (w \times d) = p \times A \times d$$

In which the values of the letters are as follows:

W = the weight of the ball in pounds.
D = the distance in inches the weight is to be placed on the lever. If placed at the extreme end, then D = the length of the lever.
W′ = the weight of the lever in pounds.
D′ = the distance of the center of gravity from the fulcrum, in inches.
w = weight of the valve and steam in pounds.
d = distance the center of the valve is from the fulcrum.
p = pressure of steam in pounds per square inch, acting upward against the valve.
A = the area of the valve in square inches.

The foregoing statement is called "the equality of moments" of the safety valve problem, and any statement, rule, or formula, which will stand the test of having the standard formula as just given applied to it, is correct in its results. An example will show how it may be applied: Required the weight to be placed at the end of a safety valve lever, under the following conditions, and with the following data:

(1) Diameter of valve 4 in.
(2) Area of valve 12.5664 sq. in.
(3) Pressure per square inch 100 lb.
(4) Weight of the lever 20 lb.
(5) Weight of the valve and stem 10 lb.
(6) Total upward pressure on valve 1256.64 lb.
(7) Center of gravity of lever 10 in , or one-half the length which is 20 in.
(8) Distance from fulcrum to center of valve is 2 in.

The problem is: What weight must be placed at the extreme end of the lever—which is 20 in. from the fulcrum—to balance the upward pressure of steam against the area of the valve?

Let us first apply Roper's rule to the problem, and see if it gives correct results. Following Roper's, the statement becomes:

$$\frac{12.5664 \times 100 \times 2 - (20 \times 10 + 10 \times 2)}{20} = 114.664 \text{ lb.}$$

The numerical values in this statement can be traced back to the values given in the question, and also compared with the letter values in the equality of moments formula.

Weight to hang at the end of the lever 20 in. from the fulcrum.

Now let us see if the 114.664 lb. answer is correct, when tested by the equality of moments given before.

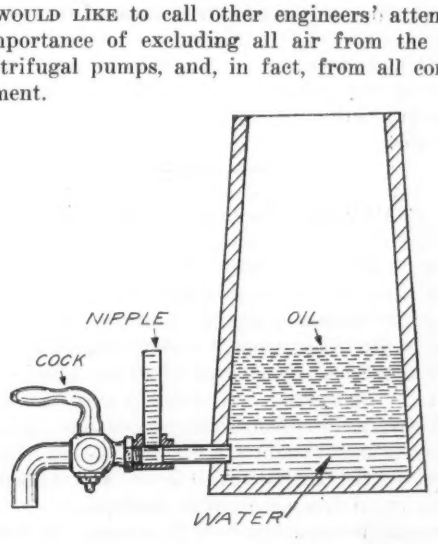
$$W \times D + W' \times D' + w \times d = p \times A \times d$$
$$(114.664 \times 20) + (20 \times 10) + (10 \times 2) = 100 \times 12\,5664 \times 2$$
$$229\,328 + 200 + 20 = 2513.28$$
$$2513.28 = 2513.28$$

If the 114.664 answer as found by Roper's rule had not been correct, then the value on the left side of the equation (2513.28 at present) would have been something else. But as it is, the left and right values are the same exactly, therefore the answer as found must be correct.

The same answer would have been obtained had the I. C. S. rule been used, or had Reed's Engineers' Handbook rule been used. So, by testing the result of any rule that may be used, by the equality of moments formula, in the way that I have shown, it can be determined whether or not the rule is correct; however, it must be remembered that all the factors involved must be used, in order to obtain correct results, no matter what form of expression may be used in the solution. A careful study of the foregoing will, I am sure, make clear to those who have had trouble with the problem, just what to do, and how to do it. CHARLES J. MASON.

Stopping Air Leaks; Removing Condensate from Crankcase

I WOULD LIKE to call other engineers' attention to the importance of excluding all air from the suction of centrifugal pumps, and, in fact, from all condenser equipment.



NOVEL SCHEME FOR DRAINING WATER FROM OIL WELL

In overhauling our circulator pump, which is a double suction turbine centrifugal of 1500 g.p.m., capacity at 1800 r.p.m., we found the water passages to the stuffing boxes clogged up so no sealing water could get

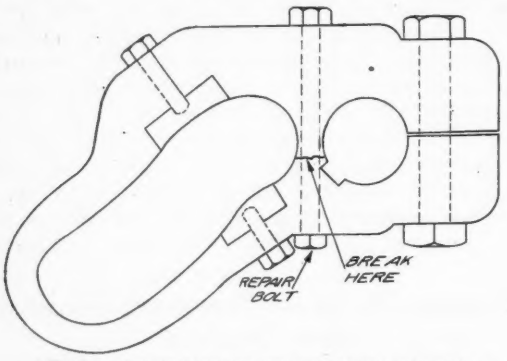
to the shaft. Some air was leaking in, but not enough to show at the discharge, or to cause the engine to race. Now the pump puts enough more cooling water through the condenser to lower the vacuum from 28 to 29 in. Keep a little water dripping from the glands, then you know they are not leaking air.

We have two small vertical engines of the enclosed self-oiling type, with an oil well in the base, and as they are idle at least part of the time, more or less water from condensation will find its way into the oil. To keep the water drained out, I put in a "T" and a short piece of ¼-in. pipe, as illustrated.

Make the nipple the height you want the oil to stand in the well, and it will never fill up with water and cause the oil to overflow. E. POTTER LOCKWOOD.

Valve Gear Repair

I WAS called upon recently to set the valves of a Harrisburg Fleming non-releasing Corliss type engine which had failed to operate, for the reason that the valve stem slipped in the link. The cause for this was found to be a break in the casting, as illustrated. Holes were drilled through the casting where the break



METHOD OF REPAIRING THE BROKEN CASTING

occurred and bolts put in to hold the parts together. Tightening the clamping bolt effectually gripped the valve stem, and after the valves were set the engine ran properly. JAMES BINGHAM.

Automatic Combustion Control

THE DISCUSSION on automatic combustion control has appealed to me not a little. We all know that economy or waste (and, generally, I'm afraid, it is waste) begins in the boiler room. A pound of coal or oil or a foot of gas lost in the boiler room is never reclaimed.

How often have you heard of 80 per cent boiler efficiency? A plant that can show 70 per cent efficiency day after day, is making some record and 70 per cent efficiency cannot obtain if too much, or too little air is supplied to the furnaces. I never was a believer in letting a lot of free air in over the fires.

"It will prevent smoke," they say, "to let in air over the fires."

"But will it save fuel?" is the question.

Mr. Van Brunt, in the Feb. 15 issue, makes it appear that, "there ain't no such animal," but in the Mar. 15 issue K. Rankin's chart speaks for itself.

The balanced draft, that is to say, the equalization of air pressure in the fire box or between fire box and combustion chamber, solves the problem in a very nice manner. The theory of this balanced condition and the operation to secure it are two entirely different problems, however.

Mr. Rankin in his article says, in part: "Apparently, the idea is too prevalent that all that is necessary is to install automatic equipment, after which operation and efficiency will take care of themselves."

In the automatic control that made the good chart, a little carelessness in the handling of the control would have spoiled everything.

The parts must be kept clean, and as free from friction as possible, then with proper adjustment the apparatus will work O. K. As Mr. Rankin says, or implies, automatic machinery requires a head to keep it automatic.

Some time ago, I was in a station of several thousand kilowatts and seeing that automatic balanced draft equipment was in service, I asked how the control operated.

"Not very well. Know anything about it? Here's the animal in this little box. Theory's all right, of course, but don't amount to a damn in practice. This thing sticks and throws us all out."

"This thing," was the stem to the pilot valve. Poor little stem was all soot; no wonder it stuck.

"Why don't you clean the machine a little bit?" I asked. "Probably the surprise will start it working."

I was in the same station not long ago. A new chief had charge and the automatic balanced draft is working perfectly.

If Mr. Rankin can make a chart as perfect as that shown—and I know he can—there is not much use in crying over inefficient regulators. TOM THUMB.

Engineers' License Law

I BELIEVE the best way to make an engineer is to give him a good education, and that only means to increase his ability to think and reason out the problems that come up for him to solve, for only by reason of being able to think and direct and work out these problems more successfully is one man more valuable than another. Thus I say, get and keep getting knowledge, for it is the greatest need of man today.

Having gained some education, the power to think and reason, next comes the time for gaining our first practical experience and proving to ourselves and others that we can think by going into the field and doing things.

Get into a good plant under a good hard master who has proven himself "master" and go to work keeping your eyes open. Having gained an amount of actual experience, you are now ready to ask the examiners (if in a license state) to pass on your ability to go up a step by granting you a license according to your ability. Don't feel too disappointed if they do not grant you the grade you think you ought to get; just go back and "plug" some more.

I think education should come first, works next, and last we must let the public know our capabilities, responsibilities and worth to the industry and community in which we live.

Most of our employers are very busy men, and as long as things are going quietly, they nearly forget that we are around; but let trouble start in the power plant, and they know who we are then and we get a hearing. We need some means of getting to the public and our employer direct.

The engineer looks after the safety and handling of a large amount of property, lives, and a great number of the comforts of modern civilization; yet, as a class, he has been underpaid, accepted as an evil to be endured, seldom consulted as long as wheels were turning.

I spent 20 yr. as an engineer in a state without a license law and I found good engineers there as well as here, where licenses are required.

An engineer who has made the most of his opportunities there need not fear the examiners. A man must "plug" in either case in order to succeed; it is not state or laws that make the man, it is what he aims to be and the amount of push or effort he puts into it that counts. I say, join the N. A. S. E. and help each other to gain all the knowledge we can. Don't be afraid to give your ideas to benefit others.

I am for a state license law for each state, and it does not matter how they are graded; the man who "plugs" will get to the top in the end.

M. W. CARTEE.

Water Softening in Small Plants

THE LETTER of J. B. in the Mar. 15 issue cites an experience which is certainly interesting and one which would doubtless throw some light on the subject if it were fully investigated and all the facts known.

The quick change in quality of the water mentioned is, of course, unusual, and it seems to the writer that if J. B. would run tests on his water treatment, say every 30 min. or even every hour, he ought to be able to control his excess chemical by diluting his chemical solution in the proportion shown by the test.

It probably would also pay him to put in a big storage tank which could be filled with water, tested, and then the treatment regulated accordingly.

If, as stated, the feed temperature is only 110 deg., it is possible that some of the pitting would be eliminated if the feed water temperature were boosted to 212 deg., since considerable air and gases would be driven off at the higher temperature and possibly also it might relieve the pitting if the softener tank were vented to relieve any air or gases.

M. A. SALLER.

Carefulness Always in Demand

SELDOM does a week pass but that I hear of, or witness, a few accidents due to the manner in which people handle doors. Instead of starting the door gently as a signal to anybody who may be approaching the other side, the door is opened with great force. The result has been broken spectacles, skinned knuckles, bruised foreheads, bloody noses, and so on. If the party on the inside happened to be in a stooping position, or if there should be an infant within striking distance of the door's travel, more serious results would surely ensue.

In factories and offices where it is necessary for many people to pass to and from certain rooms, it may not be practical to use divided, swinging doors, yet it may be systematically arranged to permit admittance only through one door and egress through another, thereby minimizing the chance of anybody being injured.

When it is practicable to use divided doors, it should be done and the pass-word rigidly obeyed: "Keep to the Right." Never walk into a room and stop directly in front of a door that opens inwardly. You are almost sure to be hit by the next comer.

Slacken your speed as you grasp a door knob and open it gently.

As you approach a door preparatory to using it, do so in such a position that you may avoid being struck should the party on the opposite side thrust the door toward you.

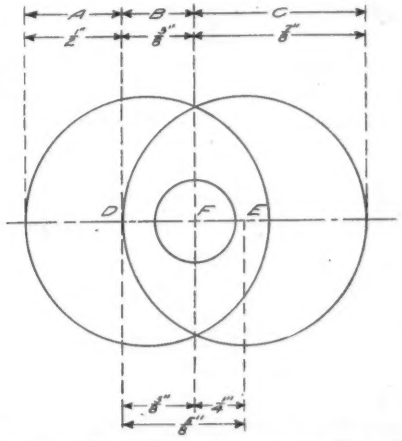
Get the proper habit and then let it grow.

J. B. DILLON.

Unusual Conception of Slide Valve Travel

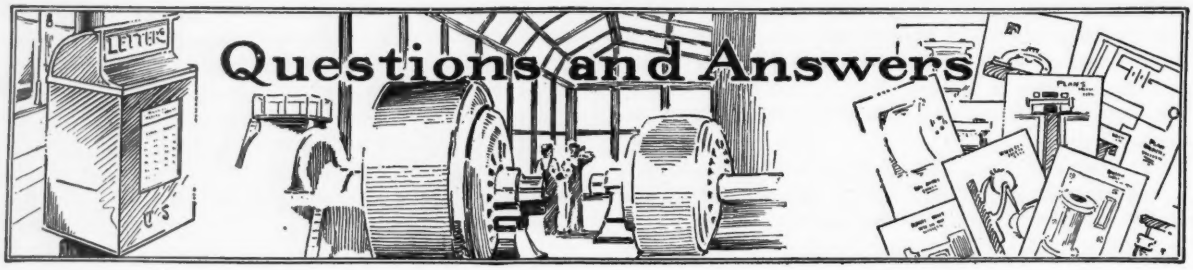
IN THE March 1 issue of Power Plant Engineering you publish a letter with the above heading. I desire to point out that the unusual part of this conception is founded on a misunderstanding of the term "eccentricity".

This term is defined in the Standard dictionary as "the distance between the centers of two circles, especially where one surrounds the other," which means, as applied to the eccentric, the distance between the geometrical center of the eccentric and the center of the shaft.



FROM SHAFT CENTER F TO E IS THE ECCENTRICITY

Let us look at the illustration given by your correspondent, which is reproduced herewith, with a few additional dimensions. The diameter of the eccentric is B plus C, or 1¼ in. The center of the eccentric is then one-half this distance, or ⅝ in., from the point marked D. This center I have marked E. The distance from the shaft center, F, to the point, E, is ⅝ minus ⅜, or ¼ in. This distance (¼ in.) is the eccentricity in this case. The statement in the letter referred to above, "subtracting B from C gives up the eccentricity," is untrue. This subtraction gives twice the eccentricity in every case. The valve travel is equal to the distance A, as your correspondent has said; but this distance is twice the eccentricity of the eccentric, which is in accord with the standard rule for the relation of valve travel to eccentricity. LOCKWOOD N. STREET



Grates Burn—Proposed Remedy

WE HAVE a traveling grate stoker serving a Heine boiler and are experiencing no end of trouble, the grate clips burning. There seems to be no regular place for the burning to take place first; but once a spot begins to burn, it increases in size very rapidly, necessitating a renewal of the clips in about six weeks. In some parts of the grate, the ends of the clips will start to burn first, leaving a hole between sections and spreading to extend one-fourth to one-half way across the grate. At other parts of the grate, we will find that the center of the clips directly over the support shows the most severe burning.

We burn Illinois nut coal and obtain an intensely hot fire even when the boiler is operating at only normal rating. If we try to force the boiler, the temperature is so high that we have melted the ignition arch.

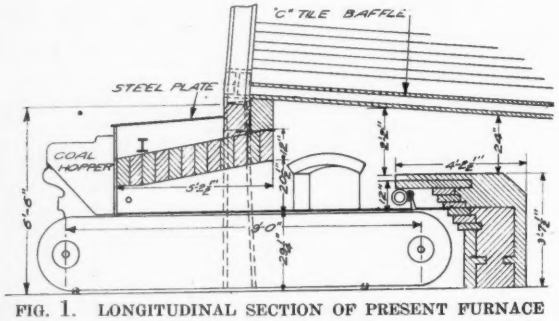


FIG. 1. LONGITUDINAL SECTION OF PRESENT FURNACE

We are of the opinion that the burning of the grate clips is not a fault of the grate design but primarily due to the high furnace temperature, and propose to make some changes in the furnace design.

Apparently the heat is bottled up in the furnace and the gases must pass clear to the rear of the first baffle before any of the heat is given up to the water. Also the limited furnace volume and the long ignition arch have a tendency to reflect the intense heat down upon the grates instead of on to the boiler tubes. It would be impractical to raise the ignition arch and maintain its present inclination, so we propose to rebuild it as shown in Fig. 2.

We also propose to remove the C tile baffle from the lower row of boiler tubes and place a T tile baffle on the second row of tubes, thus exposing the entire lower row and half of the second row of tubes to radiated heat from the grate.

These changes, we believe, should lower the temperature of the furnace, but not sufficiently to interfere with proper combustion, thus preventing the burning of grate clips and the melting of furnace lining and enabling us to carry a greater load on the boiler. At present, our flue gas temperature runs about 625 deg. F., and the change we propose should, we believe, lower this temperature.

Our city ordinances are very strict in regard to smoke abatement, but we have never been offenders of the law and naturally wish to remain in the good graces of the city officials. We have some doubt, however, whether it is advisable to raise the baffle or not and should like to have the opinion of other engineers who have had experience with such settings and furnaces.

RICHARD A. CARL.

What Caused the Bag?

I HAVE a problem I would like to submit to the readers of Power Plant Engineering. The plant of which I am in charge contains two units, one direct-connected 19-amp., 75-kw., 125-hp. simple Skinner engine, the other 28.9-amp., 115-kw. belted to 125-hp. simple Skinner engine, 23 ft. centers. The engines are supplied with steam from two 150-hp. return-tubular boilers. The company has recently finished a line running to another town 8 mi. away, just doubling the load. They are now trying to drive both of the engines with one boiler. The peak load runs to 62 amp. for 2½ to 5 hr. on week nights. On Saturday nights, it will run 170 amp. for 6 hr.

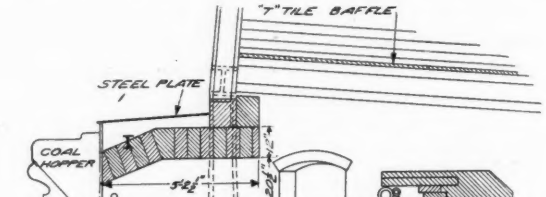


FIG. 2. PROPOSED ARRANGEMENT OF IGNITION ARCH AND BAFFLE

We tried to pull this load one Saturday. I was doing the firing so that I might know that it was not in the firing if it failed to pull the load. The superintendent of the company was present, for I had told him it couldn't be done, but he insisted that it could. Everything went well for 45 min. after the peak load hit. I don't claim to be an expert fireman, but I haven't yet met the man that I would hand the shovel to. I was forcing the boiler to every pound she was worth.

At 6:45 p. m. I left the fire door to take a peep in the engine room to see how things were going. The regular fireman took a peep in the fire box, and gave one yell,

took his cap in his hand and I did not see him again that night. I ran to the fire door and looked in. One look was enough. The boiler had 120 lb. gage pressure, and directly over the fire running for 2 ft. 9 in. back to the first lap the boiler had bagged. Up to the first lap, the boiler had a single riveted joint, which had begun to leak. I pulled the fire and got out on the other side of the plant and let the engine take the pressure off the boiler, which it did in a short time.

Now the question I would like to ask is, can you drive two engines pulling such loads at a speed of 277 r.p.m. on 120 lb. steam?

I opened the boiler next morning and got about a wash-pan full of scale and the plate showed no sign of anything that had stuck to it. I would like to ask the readers their opinions as to the cause of that boiler bagging. J. A. H.

Motor Stator as Auto Transformer

THE FOLLOWING problem has arisen and I would like to obtain advice and opinions:

We want to reduce 550-v. 3-phase 60-cycle current to 440-v. 3-phase 60-cycle, for the purpose of temporarily driving a 30-hp., a 22-hp. and a 7½-hp. motor on a Gantry crane, until new motors of proper voltage arrive.

It is suggested that we might utilize a 150-hp. 550-v. 3-phase 60-cycle squirrel-cage motor, driving it with no load and taking taps off the stator windings to obtain 440 v. This arrangement would be using the stator of this motor as an auto-transformer.

Is the foregoing practical for tiding us over for a week or so? C. F. H.

What Adjustments are Required?

WE HAVE a 26 by 48-in. Corliss engine running on the ball type of governor driven from the main shaft. At no time has the governor given satisfaction, due to racing an inability to add top weight to it. It seems that the former engineer had also had trouble with it and could not get it to work. Engine runs, on an average, from 26 to 48 r.p.m. in a sugar mill utilizing from 200 to 300 hp. We tried smaller pulleys and vice versa. Rods are true and in good order. What should be done to prevent racing and also to add weight and run properly? Card shows valves all O.K.

J. C. E.

Heating System Problems

WILL some of the readers of Power Plant Engineering please tell me what they would do to get their returns back with a steam loop if the loop should break or get out of order?

How would you get back returns on a vacuum system if the vacuum pump became disabled? H. E. H.

Disposal of Wood Waste

I HAVE recently become a subscriber to your valuable magazine and find many things that help me in my plant. I now wish to avail myself of your offer to help in answering inquiries.

The ground space on which I have installed my wood-working plant is limited and I find it necessary to arrange to dispose of the surplus mill waste, such as shavings, which the boiler does not burn and wish to know whether you can give me some suggestions as to the manner best suited where the space will not allow blowing out some distance from the mill and burning in the usual way with most plants. Is there not some way of burning them near the boiler room? If so, kindly advise the way such an arrangement should be constructed, as inexpensively as possible. V. C. A.

Can We Eliminate the Condenser?

THE PRESENT problem is how to save coal. Some engineers claim that 55 per cent of the heat of the steam is lost in the condenser. I believe that in time to come, the exhaust steam which is now turned into water and pumped back into the boilers with a loss of 55 per cent of heat will some day be saved by sending the exhaust steam direct into the boilers without the use of condensers.

Some engineers think it is impossible to get the exhaust steam back into the boilers. People once thought there would never be aeroplanes, submarines or wireless. I would like to know what the readers think of this.

J. RAIA.

Fuel Oil Burning in Vertical Watertube Boilers

ON PAGE 354, Mar. 15 issue, I note C. J. M.'s letter on the above subject. His question is not very clear, as he did not go into sufficient details. He did not state the make of boiler, the type of burners used, nor how the oil was atomized and whether with air or steam.

The first thing he should do is lower the grates and cover them with fire-brick laid checkerwork ¼ in. apart to admit air. Lowering the grates is to increase the size of the combustion space.

Next, the ash pit and furnace should be lined with fire-brick, and around the top of the furnace there should be a ring of fire-brick, built projecting towards the center of the furnace. This will deflect the flame upwards.

The fire-door should be bricked up, and sealed air-tight, air to be admitted through the ash-pit doors underneath the grates and up through the ¼-in. opening in the covering on the grates. The burners should be placed in the ash-pit door at such an angle that the flames shoot across the furnace the longest way, so as to provide ample time for complete combustion.

LESLIE KLOCK.

Furnace Alterations for Oil Burning

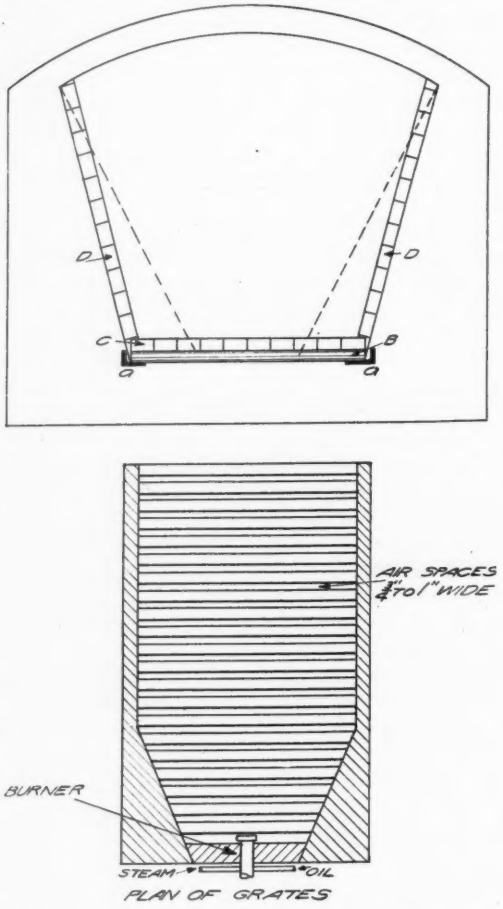
IN REGARD to C. J. M. changing a Murphy furnace for oil burning, I would say that he ned not do much changing to get good results; and, if he ever should want to go back to coal, he can do so, as the arrangement in the sketch does not alter anything except the grates. These are taken out of their present position and spread and the ends made to rest on the angle irons that run from the front of the furnace to the bridge wall. This angle should be wide enough to support also the pipes that the brick rest on.

These pipes should be cut just the right length so they will hold the grate bars on the angle iron. Place the brick on the pipes first, either on edge or flat; this

will depend on the length of the furnace; if short, put them on edge; if long, lay them flat.

Next run a small one-brick thickness all the way up the grate bars to exclude any air from getting through them. Wall up the fire doors and clean out the ash pit so you can admit air through it.

Put the burner through the front and center of your grates about 8 in. above them. Get a good nozzle on the burner so it will break up the oil in a good spray. Above all, do not put in any checker work for the oil to hit. Make the oil burn in the air, and you will be



able to force your boiler anywhere from 200 to 400 per cent rating; that is, if it is free from scale.

L. C. KAISER.

Corliss Valve Lap

I AM SURE the answer to question 11 on page 355 of the Mar. 15 number of Power Plant Engineering would not satisfy a Massachusetts examiner.

Lap is added to the steam valves of a single eccentric Corliss engine to delay their opening and thus prevent excessive lead.

In order properly to understand the reason for lap on the steam valves of a single eccentric Corliss engine we must also consider the exhaust valves.

Assuming all four valves set line and line. In order to have the exhaust valve on the end, toward which the piston is moving, close for compression at the proper time, and the exhaust valve on the other end of cylinder open for release it is necessary to advance the eccentric.

When we advance the eccentric to give the right compression and release, the steam valve on the end toward which the piston is moving, will open, resulting in excessive lead. To remedy this, we add lap to the steam valve.

On double eccentric Corliss engines, the steam valves can be set with lap, negative lap or line and line with wristplate central, and the eccentric moved ahead or backward from the 90-deg. position as the setting may require, to give the proper lead.

JOHN A. MURDOCK.

Why Does the Bearing Heat?

ON PAGE 304 of the March 1 issue, I noticed X.Y.Z.'s indicator card taken from the low-pressure cylinder of his cross-compound engine, for criticism.

He has a too early cutoff in the low-pressure cylinder, as he will see by his card that the expansion line crosses the back-pressure line and forms a loop.

If the cutoff in a low-pressure cylinder is too early, it will raise the pressure in the receiver, which, in turn, lessens the work of the high-pressure cylinder, throwing more work on the low-pressure cylinder, which would cause the bearings and eccentrics to warm up.

The power of a cross-compound engine is not materially changed by changing the settings of the valves, but in order to change the distribution of work in the two cylinders, the low-pressure cutoff must be changed.

In some compound engines, the governors control only the high-pressure cutoff, but in most compound engines the governor controls both high-pressure and low-pressure cutoffs, in that the governor operates the high-pressure cutoff to change the power of the engine and the low-pressure cutoff to equalize the work done in the two cylinders.

I think that if X. Y. Z. will make the cutoff in the low-pressure cylinder later, which will lower the pressure in the receiver, throwing more work on the high-pressure cylinder, the trouble he now has will be greatly relieved.

LESLIE KLOCK.

E. L. B.'s Diagram Criticized

IN THE March 15 issue of the paper, page 354, I note criticism is desired relative to two sets of indicator cards.

The first card—that presented by E. L. B.—shows several very bad features with regard to the valve setting and steam distribution in the engine cylinder. The steam is admitted into each end of the cylinder alternately, much too late, as indicated by the inwardly sloping lead lines, and the formation of loops on each diagram.

The compression pressure is also too high for the speed at which the engine is running. One end of the cylinder is doing more work than the other, as shown by the difference in height of the diagrams; the exhaust at each end also opens too late.

Therefore, make adjustments to secure an earlier admission of steam into the cylinder at each end, and also an earlier exhaust at each end, and less compression by about 10 or 15 lb. These suggested changes will cause the engine to run better, and also to carry the required load with less steam consumed than at present.

The card presented by E. B. may be analyzed as follows: Steam lead late at both ends of cylinder. Exhaust occurs too late at both ends, as shown by the curved back-pressure lines. The engine is overloaded, speaking from an economy standpoint, as shown by the relatively high terminal pressure at both ends of the cylinder. The diagrams show irregularity in the steam distribution throughout, and a wasteful engine in the use of steam to do the work. This engine would probably do better with higher boiler pressure.

CHARLES J. MASON.

AFTER STUDYING the indicator cards submitted by E. L. B., in the March 15 issue, the first question arising in my mind is, "Are the cards correct?" Apparently the indicator cord stretched while taking the cards, or between the taking of the two cards. It may not interfere with the general analysis of engine conditions, but such a card is not to be relied upon for accurate results in figuring power or in setting valves. Before taking indicator cards, the cord should be connected to reducing motion or crosshead and allowed to run until the stretch is all out of the cord.

From the negative loops at the admission end of both cards it would seem as though there were exhaust valve leakage, perhaps from over travel. Both compression lines start out with proper curvature, but at about half admission pressure the compression line suddenly starts to fall away. If it were due to piston leakage there would be no sudden change in the curve of compression line. There is too much compression; that is, the exhaust valve closes too quickly at both ends. The admission is too late, which, combined with the leakage above referred to, causes the negative loop.

E. L. B. has not stated whether this is a single or double eccentric valve gear. In either case I believe that the best way to remedy the valve setting would be to start with the adjustment of the reach rods from the wristplate to the valve arms. The exhaust valve rods should be shortened or lengthened (according to the way the valve gear is designed) to give the valve quicker opening and later closing. The steam valve arms should be shortened. If proper admission cannot be obtained by shortening the steam rods without causing trouble in other ways, such as too great an angle between steam valve arm and rod or too little lap of steam valve for tightness, then the steam eccentric should be moved ahead until proper admission is obtained.

The expansion lines both show signs of valve or piston leakage, which would naturally follow if there were leakage as shown by the compression lines. It may be that if this leakage is caused by over travel it will disappear when the compression is reduced.

THE INDICATOR diagrams, from a Brown engine, submitted by E. L. B. show an engine which is not doing work to the best advantage. The steam admission is late. the piston having traveled several inches before full pressure is admitted. The right-hand diagram shows a lower admission pressure than the other. The compression at the end of each stroke reaches nearly the same pressure; but the piston starting from dead center, on its stroke, increases the clearance space; the pressure falls and the steam valves opening late, a loop is formed in the line.

I think that in this case I would look for a slipped steam eccentric; advance it to give more lead. This will help your steam lines and eliminate the loop. Also look for leaky piston and valves. TOM JONES.

THE LEAD on both ends of E. L. B.'s card is entirely too late. I believe that he also has considerable more compression than is necessary and the exhaust seems quite late. I would also advise that he equalize the cutoff on both ends.

I would like to see the card he gets after making these changes; I believe that he will notice considerable improvement. FRED W. GOLDSMITH.

E. B.'s Diagram Criticized

The cards submitted by E. B. show the same signs of string stretch while taking the cards as those submitted by E. L. B.

In general, the cards show all events too late, which would be remedied by advancing the eccentric or eccentrics as the case may be.

The left-hand card will have too much compression when the rest of the events are advanced to a proper position, which can be remedied by adjusting the exhaust rod on that end or by bringing the wristplate back to a uniform travel both sides of the center line in case it is now traveling more to one side than the other.

In the answer given to question 2, page 355, I question the use of the term "fire box" which should not be used in place of the term "furnace" or "combustion chamber." Another point I would like to raise is that there are B. & W. boilers now in operation in which the tubes slope down from the rear end toward the furnace or front of the boiler.

Referring to the answer to question 11, in the case of the Corliss valve with full release the amount of steam admitted to the cylinder is entirely controlled by the cutoff gear and the lap is used to insure tightness of valve and to allow the valve to open rapidly once it starts to open. C. E. MOULSON.

THE CARD taken from a Green engine looks to be needing adjustment all over. This being a double eccentric, I would first advance the steam eccentric to get a vertical admission line on both ends. The compression curve, also the release at end of stroke, shows up late. The release especially is late, as it falls downward toward the atmospheric line, showing that the exhaust is slow in getting through the port. By advancing the exhaust eccentric, with one move we will get an earlier compression and an earlier release, and thus correct the turned up toes of the card. The expansion lines both show leakage of steam through the steam valve.

A. C. WALDRON.

To Prevent Leakage of Ammonia

WHAT DO you advise to use as a good pipe joint thread "dope" for ammonia pipe screw fittings?

R. G. S.

A. We would suggest as a good pipe joint cement for ammonia piping a soft, fresh paste of litharge and glycerine.

THE LONGER a man lives, the older a bit of truth must be before he will accept it as truth.

POWER PLANT ENGINEERING

Trade-mark, Reg. U. S. Pat. Office

Issued the 1st and 15th of each month. Established over 24 yr.

Published by the TECHNICAL PUBLISHING CO.
537 South Dearborn Street, Chicago
New York Office, 150 Nassau St.

Subscription price $1.50 a year in postal zones 1, 2, 3, 4 and 5, which include all postoffices within a distance of 1400 miles from Chicago.

Subscription price $2.00 a year in postal zones 6, 7 and 8, which include all postoffices more than 1400 miles from Chicago.

Copies, current issue, 10 cents; back numbers, 20 cents.

Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach your promptly.

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Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers.
Member, Audit Bureau of Circulations.
Circulation of this issue 24,200

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Capital's Service

There can be little argument about the necessity of capital in industry. It will be conceded that tools, machinery, buildings and a supply of materials are needed for any work, and these are capital. The two questions are, shall capital be furnished by private ownership or by common ownership? And what return shall be allowed to the owners of capital for its use?

The feeling that under private ownership some individuals control an undue share of capital is probably responsible for the propaganda for government or communistic ownership. Distributed ownership is now largely accomplished by corporations and the selling of bonds and stock; so that unless the title to capital be taken over by the government, the only thing to be accomplished by government interference would be a confiscation of property and equalization of distribution. It has been shown repeatedly that such equalization would be only temporary, for those willing to save and plan would again soon have acquired larger holdings than those who spent heedlessly.

But it is interesting to note just what the effect of such an equalization would be, if it were accomplished. If all wealth, including houses, clothing, tools, machinery, factories, warehouses, stores, materials, transportation systems cattle etc., were collected and evenly divided, the value given to each person in the country would be about $512. Anybody now having more than that would have to surrender the ownership of the part of his goods above the value of $512, and in this value would be included clothing, furniture, personal effects; so that few but would find themselves worse off than before the division. Only the thriftless would gain.

As to government ownership proper, this carries, almost certainly, government management of industry. With the examples before us of cost of government construction of public works, inefficiency of operation of government departments, the poor present service of the postoffice, and the recent muddle of railroad operation, it would be a brave man who could contemplate hopefully the throwing of management of farms, factories, stores and offices into the hands of government officials and bureaus. It is inconceivable that anything like even present low production could be maintained.

What, then, is the service of capital? Who benefits from it? How can this service be made of greatest value to the people?

In the first place, it must be remembered that money, except the gold and silver in coins, is of itself of no value to industry. Only as it represents ownership can it be made to help. Money hoarded, then, is of no value to industry or to the community. In fact, it is a detriment, for it represents the saved products of industry that should be put to work to give further opportunities for labor. And there must be capital invested if workers are to have work. A man in the middle of a prairie or a forest, with no tools or supplies is the typical case of a worker with no capital. His chances for getting ahead, for producing anything on which he can live, or of making savings are very small.

Give him tools, cattle, seeds, he has a good chance to produce, and to save, to increase his capital, with ever increasing chance for production. But, if he consumes

all that he produces, of food, clothing, fuel, he will make no progress. There must be something saved from his production, so that his capital may be increased. Then he will be in position to employ other men.

If, however, those employed are to receive all that they produce—using his tools, cattle and seeds—there will be no incentive for him to save. He will say, "Let them do their own saving."

We have progressed far from this simple condition, but the principles still hold true. To expand, industry must have more capital, and this must come from an excess of production over consumption—from savings. At present, production is low, consumption is high, and demand is greater than the supply. More production is needed and less consumption. What can bring about the desired result?

If capital is to have no return for its use in industry, either nobody will save, or savings will be hoarded, so as to avoid risk of loss. Industry cannot progress, and the demand for workers will slacken.

If capital be allowed a fair return in interest or dividends, it will be invested in industry and furnish jobs. Evidently no worker is entitled to use another man's savings unless he pays from the product of his labor for the use of those savings. What he produces has a certain value in the market, based on the demand for and the supply of his product. He is entitled not to that total value, but to the part that is left after he has paid for the use of the capital furnished by others in the form of tools, machinery, buildings and materials.

If he is capable and industrious, he can increase his production and should receive added wages—and vice-versa. That is obviously fair. But any employer who hires both capital and workers has to pay for them out of the price received for the product. He cannot employ workers unless he gets the capital needed, and he must pay the market price for capital. Unless the workers produce sufficient to be worth more than the price of capital and the wages paid to them, the employer has nothing to pay him for his own work and for the risk he has run in taking the responsibility for the business.

He is, therefore, entitled to profit above his costs for capital and wages. But he must recognize, if he be fair, that workers who increase their output are entitled to a share in the increased profits, just as he is entitled to a share of the increase if he hires more capital to put in better machinery and buildings so that the workers can increase output and get better wages.

Both employers and workers need capital to conduct industry. Whether the capital be furnished by employer, by workers, or by somebody outside the organization, each owner of capital is entitled to a return for its use. The worker is entitled to payment according to his output, but not to all the value of his output. And the employer is entitled to a profit for his skill and responsibility. Each of the three, employer, worker and owner of capital should recognize their common interest in industry, and the rights of the others, if the greatest success is to be achieved and production to reach its maximum. And this maximum of production is essential if industry is to be placed on a secure basis, prices to be lowered and easy living conditions to be possible. Controversy, low production and high consumption can only result in continued high prices, unrest and difficulty in "making ends meet," both in industry and in the home.

Our Oil Resources

IT IS without question of exceedingly great importance that an accurate survey be made of our oil resources, present and prospective; but, who is to make this survey? How is it to be carried out? These are two important questions. Naturally, the first suggestion can be carried out by the Government through the Bureau of Mines, or through a special organization, either in the Bureau of Mines, or separately therefrom. There is a certain tendency to be impatient and furthermore to be doubtful of the results of a Government investigation of this kind. Just exactly why this attitude should be taken is a somewhat difficult thing to answer, but it seems that there is a certain amount of fear that such a committee would be biased politically and a certain feeling that the investigation would be more or less superficial. We do not believe that the Bureau of Mines has ever been accused justly of being superficial in its work. As to the danger of a political bias, we believe this danger is 99 per cent imaginary. The question as to the method is one that should be left more or less to the committee undertaking the investigation. It is certain that the average oil man cannot be depended upon to offer any assistance. About all the oil man thinks of is the price he is going to get for his oil. He does not care in the least what the future of the oil is going to be, nor whether he would go to open up new territories in case those which he was immediately interested in were to be exhausted. It has been asserted at different times that a certain amount of oil was locked in the bosom of the earth and that when this certain amount was exhausted, there would be no more. Various figures have been given, and various times have been set for the exhaustion of our oil supply. As a matter of fact, with all due respect to the minerologist in oil and oil wells, he has a long way to go before he can estimate with any degree of accuracy just what is our future supply of oil. This is very well shown by the fact that from time to time new oil fields are opened in territories where no oil was suspected beforehand. We could make an estimate, perhaps, on the present fields at the rate of flow, and compare them with other and older wells, and make a rough estimate of what the limit of production is to be; but even this is more or less a matter of guesswork. The fact remains that we cannot inventory our oil supply as we can a stock of goods in a store or warehouse. Therefore the best we can do is to make an intelligent estimate based upon a systematic investigation of oil prospects throughout the country, aided perhaps by occasional test wells to determine the possibility of a new field, in a certain territory. Even then, when it is considered that an oil field is often confined to exceedingly narrow limits, it is a question of whether a test well is always the final answer to the question of whether or not there is oil in a certain territory.—The Gas Engine.

DON'T make it necessary to have someone put over you to see that you keep up the pressure in your boiler. —Forbes.

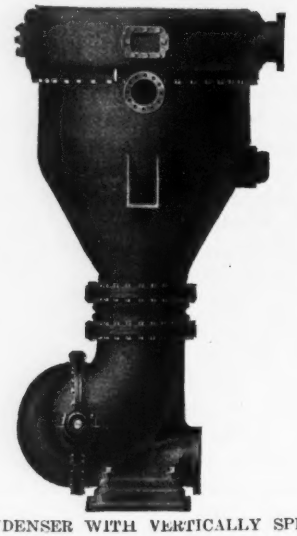
Important Improvement in Jet Condensers

THE illustration herewith shows the latest design in vertical jet condensers. The new feature is the vertically split casing of the tail pump.

This feature permits easy and quick removal or inspection of the pump rotor or other internal part. It is now simply a matter of removing the bolts and cover and uncoupling the rotor. Before this design was developed, considerable time was required to get at and remove the rotor.

The improvement is now being added to two types of jet condensers—the vertical jet condenser and the rectangular type counter-current condenser.

Another feature worthy of note is the expansion joint between the pump and the condenser body. This joint is designed to take care of any changes in length due to temperature fluctuation. In some installations the expansion joint is not recommended, hence condensers are made with or without the joint, depending upon the conditions in the plant.



JET CONDENSER WITH VERTICALLY SPLIT TAIL PUMP CASING

The primary advantage claimed for this type of jet condenser lies in the fact that it utilizes the heat-absorbing capacity of the cooling water to the greatest degree, discharging it from the bottom of the condenser at practically the same temperature as the steam. At the same time, the outgoing noncondensible gases come into contact with the water entering at the top of the shell and are therefore cooled to the lowest temperature.

Referring to the illustration, steam and water enter at the top. The water is discharged in streams through spiral nozzles, which break up the water current into a rain or spray to insure the desired steam-condensing capacity. The condensed steam and water fall to the bottom of the condenser, where they are removed by the submerged centrifugal pump. The air is removed through an opening just below the cone of the condenser, a small amount of cold water being allowed to fall just in front of the air outlet, thus cooling these gases to their smallest volume.

In connection with these condensers, a turbo-air pump or a three-stage steam jet air pump is usually recommended.

Forged Return Bend

IN MACHINERY and equipment such as condensers, stills, etc., for refrigerating and other plants employing pipe coils in one form or another, it is frequently a great advantage to have such coils as nearly as possible in one piece. To attain this object resort

FIG. 1. PLAIN RETURN CUT AWAY TO SHOW EXTRA THICKNESS OF METAL

in the past has been had to welding or brazing with more or less success.

There has recently been developed, however, a method of forging the joints of such coils, with the result, it is

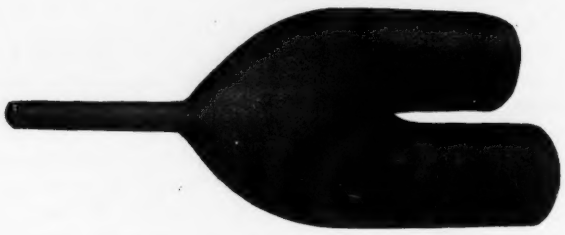


FIG. 2. RETURN BEND WITH SUPPORT

claimed, that the joint thus made is even stronger than the pipe itself. No metal other than that of the pipe itself is used, the result being that coils made by this process are one continuous piece of tube. Furthermore, the cross-section throughout being uniform, the frictional resistance to the flow of the fluid handled is reduced to a minimum.

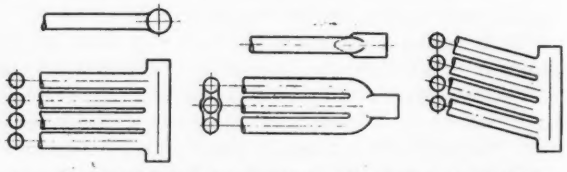


FIG. 3. EXAMPLES OF SPECIAL COIL ENDS AVAILABLE BY FORGING

Figure 1 is a plain return bend cut open to show the extra thickness of metal in the outside of the bend. Another form of bend having a support forged solid with the pipe is shown in Fig. 2. In addition to its use in the manufacture of pipe bends, this process is also applicable to production of ceiling or wall coils for heating or refrigerating plants. Three typical coil ends

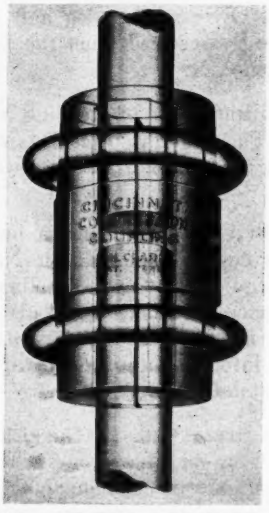
of this class are shown in Fig. 3. Forged coils are subjected at the factory to a hydrostatic test of 800 lb. per square inch.

A New Compression Coupling

A NOTABLE saving in the time and labor that heretofore has been required for connecting line shafting, has been effected by a new type of compression coupling now being manufactured. Some idea of this coupling can be obtained from the accompanying illustration. Probably its outstanding feature is its simplicity; it can be installed on any kind of a shaft in 5 min. time. It is adapted for use in every industry where power is transmitted by line shafting.

The construction of the new coupling consists of only five pieces, three jaws and two clamping rings. The jaws of the coupling are placed in position about the shaft, and held in place by the longitudinal grooves and notches that lock them together. The forged clamping rings are pushed on over the tapering ends of the jaws, and hammered tight.

A hammer is all that is required for installing the coupling. It is only necessary to have sufficient clearance between the two loose ends of the shaft to allow the passing of the clamping rings.



PHANTOM VIEW OF NEW COMPRESSION COUPLING

The coupling grips the joined sections of the shaft, holding them in alinement. The round, machined sections of the tapered end of the coupling jaws form lines of contact for each ring.

The assembled coupling forms a clean, compact shaft joint. There are no projections on its outer surface to catch a workman's clothing, an important detail in this day of safety for employes.

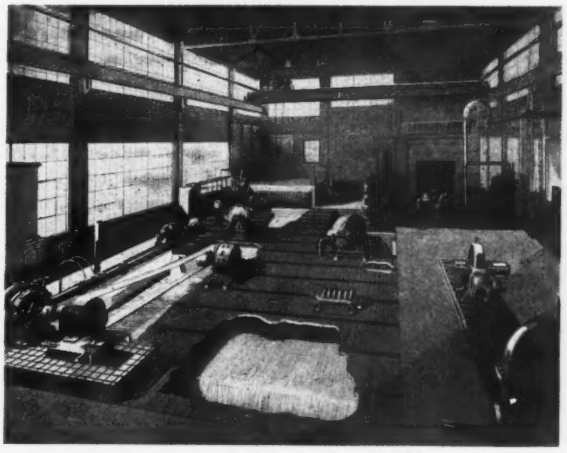
When used as a reducing coupling, the only additional parts needed are three strips of cold-rolled steel to fit between the smaller shaft and the inside of the coupling jaws.

Low temperatures retard the initial hardening of concrete. So, when you work in freezing weather, heat the aggregates and water to a mass temperature of at least 80 deg. F.—Successful Methods.

A New Pump and Turbine Testing Plant

AN IMPORTANT factor in the operating success of power plant apparatus is the factory test before delivery of the equipment. Tests of this kind should be conducted under conditions as nearly as possible like those occurring in practical operation. Accurate measurements should be taken and records made of the data thus secured.

One of the most recently-built plants for making such tests is that of the Midwest Engine Co. The building itself contains about 5000 sq. ft. of space, equipped for testing centrifugal pumps up to 48-in. discharge, as well as reciprocating pumps and steam turbines.



GENERAL VIEW OF TESTING PLANT

The pump testing equipment handles up to a maximum discharge of 25,000 gal. per min. and is provided with three concrete tanks with calibrated weirs. For deep well and sump pump tests a deep sump is provided. Pressure and flow indicating meter readings are recorded at various stages during the test. The driving equipment consists of motors and steam turbines of various sizes and speeds. A turbo-generator set delivering both d.c. and a.c., together with transformer equipment, furnishes the current necessary for the motor-driven units.

There are sufficient facilities for testing five steam turbines at one time, using steam at any desired pressure or degree of superheat. A condenser containing 2000 sq. ft. of surface is provided for condensing units. Power tests are conducted with water and proving brakes, and the actual steam consumption is determined by a careful weighing of condensate. As nearly as possible, actual operating conditions are simulated.

Trade News

D. T. NEWMAN, formerly connected with the Philadelphia sales office of the Yarnall-Waring Co., has been placed in charge of that company's Atlanta office, recently opened in the Candler Annex.

THE HOMESTEAD VALVE MFG. CO., of Homestead, Pa., announces the removal of its New York office to 242 Lafayette St. This new office is in charge of P. L.

Rhodes, who has with him William Gormly, John Gormly, George Nagle, C. A. Tyler and W. B. Goering.

G. T. SCHUSHAN is now Chicago representative for the Taber Pump Co., of Buffalo, N. Y., manufacturer of rotary and reciprocating pump and gas collecting and carbonating plants.

AT THE ANNUAL MEETING of Midwest Forge & Steel Co., of East St. Louis, Ill., the following new officers were elected: J. W. Eschenbrenner, president and treasurer; C. T. Coates, vice-president and general manager; E. A. Eschenbrenner, secretary.

THE CURTIS & CURTIS CO., of Bridgeport, Conn., manufacturer of the Forbes' pipe threading and cutting machine, has received a "Certificate of Merit" from the War Department for its patriotic service during the war. This citation is expressly for "making prompt deliveries and otherwise co-operating with the Construction Division of the Army."

OF GENERAL INTEREST is the combination recently announced of the organizations of Westinghouse, Church, Kerr & Co., Inc., Engineers and Constructors, New York, and Dwight P. Robinson Co., Inc., Constructing and Consulting Engineers, of New York.

The new company will be called Dwight P. Robinson & Co., Inc., and will occupy executive offices at 61 Broadway and engineering and designing offices in the Grand Central Palace, 125 East 46th St., New York.

THE GENERAL OFFICES of the Chicago Pneumatic Tool Co. have been transferred to the Chicago Pneumatic Building, a new 10-story structure erected for the exclusive use of the company at 6 East 44th St., New York.

The Chicago District Sales Branch, previously in the Fisher Building, has been moved to 300 North Michigan Blvd. The Chicago Service Branch, formerly at 521 South Dearborn St., has been consolidated with the Sales Branch at the new address, occupying the first floor of the building, while the sales offices will be on the second floor or boulevard level.

CHARLES C. PHELPS recently became associated with the Uehling Instrument Co., 71 Broadway, New York, combustion engineers and manufacturers of CO_2 recording equipment and other fuel economy apparatus. Mr. Phelps graduated from Stevens Institute of Technology with the degree of Mechanical Engineer and has since spent several years studying power plant problems. For 5 yr. of this period, he was connected with the Ingersoll-Rand Co., manufacturers of power plant equipment and pneumatic machinery. Mr. Phelps is an Associate Member of the American Society of Mechanical Engineers.

ANTI-CORROSION ENGINEERING CO. is the title of an organization recently formed in New York City for the purpose of bringing before the engineering and plumbing trades the Speller and other methods for the prevention of rust in pipes. This is accomplished by the removal of the dissolved oxygen from the water carried and it is the several methods devised that the Anti-Corrosion Engineering Co. has put into practical form.

The president and general manager of the new company is Dr. C. V. Paterno, while F. N. Speller, metallurgical engineer, is the vice-president. On the staff of consultants are J. F. Musselman and Dr. W. H. Walker.

TWO NEW BUILDINGS, one for the manufacture of recording thermometers, the second a research department, and at a cost of $100,000, are being erected by The Brown Instrument Co., Philadelphia, Pa.

THE OXWELD ACETYLENE CO., of Newark, N. J., and Chicago, has recently extended its manufacture of oxy-acetylene apparatus and equipment to include "Eveready" welding and cutting outfits. "Eveready" is the new name in the oxy-acetylene field; but the apparatus is not new, excepting for certain refinements of design, having been used extensively in the metal-working trades for several years under the name of "Prest-O-Lite" apparatus.

DUE TO its rapid growth and the demand for self-feeding bucket loaders and standardized belt conveyors, Barber Greene Co. has found it necessary to make certain additions and changes in its selling organization. The company is now represented in St. Louis by R. E. Foulke, 404 3rd National Bank Bldg.; in Pittsburgh by J. A. Gurney, 605-606 Arrott Bldg.; in Philadelphia by F. S. Sawyer, 1010 Penn Square Bldg.; in Indianapolis by W. T. MacDonald, 305 Merchants Bank Bldg.

DART UNION FITTINGS catalog and price list of 31 pages was recently received from the E. M. Dart Mfg. Co., of Providence, R. I.

CATALOG NUMBER ONE of Reading Valve & Fittings Co., Reading, Pa., contains price lists and illustrations of the company's flanged and screwed fittings and flanges.

THE STAR BRASS WORKS, Chicago, now has ready for distribution its new 24-page bulletin, No. 4-A, covering spray cooling equipment for the cooling of water from steam and ammonia condensers. This literature gives illustrations of many recent installations, in addition to much valuable information respecting spray cooling systems for power and industrial plants.

ARMSTRONG STEAM TRAP is the title of Catalog E, recently issued by the Armstrong Machine Works, of Three Rivers, Mich. In addition to the matter dealing with the products of this company, considerable information of an engineering nature is embodied in the booklet, thus rendering it of considerable value to those in charge of steam generating plants and distribution systems.

SMOOTH-ON HOME REPAIRS is the title of a booklet just published by the Smooth-On Manufacturing Co. In this book has been explained how to repair leaks in boilers, radiators, furnaces, tanks and the many other fixtures that need attention from time to time. There are from 30 to 40 different kinds of repairs with the remedy illustrated and explained.

The use of Smooth-On in combustion engine repairs receives attention also in this book. Cracked water jackets, leaky radiators, scored cylinder, etc., are all taken up and their repairs explained.

Every engineer can get a copy of this book on request to the Smooth-On Manufacturing Co., Jersey City, N. J.